Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior

TITLE

Curricula having focus on employability/ entrepreneurship/ skill development

- Program-1 B.Sc. (Hons) Agriculture
- Program-2 B.Sc. (Hons) Horticulture
- Program-(3-15) M.Sc. Agriculture & Horticulture
- Program-16 Ph.D. Program

Font in red colour denotes Curricula Having Focus on Employability, Entrepreneurship and Skill Development

PROGRAMME-1

B.Sc. (Hons.)

Agriculture

Department – Agronomy

1. AGR – 111 (Fundamentals of Agronomy)

Credit Hours: 4 (3+1)

Topics in Theory:

S. No.	Topics
1.	Agro-climatic zones of India and Madhya Pradesh and agro-ecological classification, Agriculture-definition and importance of agriculture
2.	Agronomy-meaning and scope of Agronomy, types of seeds, dormancy of seeds, viability of seeds,
3.	Seed treatment, sowing-methods, depth, plant density and geometry, nursery bed and transplanting, optimum plant population
4.	Tillage-definition and types of tillage including minimum and no tillage.
5.	Tilth-definition and characteristics of good tilth.
6.	Crop nutrition-essential nutrients-classification
7.	Nutrient mobility in plants, Factors affecting nutrient availability
8.	Functions and deficiency symptoms of primary nutrients
9.	Manures –types, nutrient content,
10.	Green manures, compost
11.	Fertilizers, INM
12.	Nutrient use efficiency
13.	Irrigation: definition and objectives
14.	Water resources and irrigation development in India and Rajasthan.
15.	Soil moisture constants and theories of soil water availability
16.	Crop water requirement and factors affecting it
17.	Scheduling of irrigation: meaning and different approaches for scheduling irrigation in field crops.
18.	Surface methods of irrigation; border, furrow , check basin and basin methods
19.	Sprinkler and drip methods; their layout, adaptability, advantages and limitations.
20.	Irrigation efficiency; different terms used and their importance.
21.	Water use efficiency -factors affecting and agronomic techniques to boost WUE
22.	Irrigation water quality-different criteria and limits used, effect of poor-quality water on plant growth.
23.	Management practices for efficient use of poor-quality waters including conjunctive use of water.
24.	Agricultural drainage-definition, benefits and different methods of drainage.
25.	Growth and development of crops, factors affecting growth and development,
26.	Plant ideotypes, crop rotation and its principles,
27.	Adaptation and distribution of crops,
28.	Crop management technologies in problematic areas,

29.	Harvesting and threshing of crops
30.	Weeds – definition, harmful and beneficial effects and classification
31.	Ecology of weeds
32.	Weed - reproduction and seed dissemination
33.	Crop-weed competition-concept and allelopathy
34.	Concepts of weed prevention, eradication and weed control
35.	Physical and cultural methods of weed control
36.	Chemical and biological methods of weed control
37.	Integrated weed management - An introduction
38.	Introduction to herbicides, advantages and limitations of herbicides usages
39.	Classification of herbicides

Topics in Practical:

S. No.	Topics
1.	Identification of crops, seeds, fertilizers,
2.	Common Pesticides in agriculture
3.	Study of agro-climatic zones of India and Madhya Pradesh
4.	Identification of weeds in crops
5.	Methods of herbicide and fertilizer application.
6.	Study of yield contributing characters and yield estimation,
7.	Seed germination and viability test
8.	Numerical exercises on fertilizer requirement of crops
9.	Plant geometry and plant population of various crops
10.	Herbicides requirement calculations and water requirement
11.	Use of tillage implements-reversible plough, one way plough, harrow, leveller, seed drill
12.	Study of soil moisture measuring devices
13.	Measurement of field capacity and irrigation water
14.	Determination of bulk density and infiltration rate

Suggested Readings:

- ICAR. 2010. Handbook of Agriculture (6th edition), Indian Council of Agricultural Research, New Delhi.
- Panda, S.C. 2012. Modern Concepts and Advance Principles in Crop Production. Agrobios (India), Jodhpur
- Balasubramaniyan, P. and Palaniappan, S.P.2016. Principles and Practices of Agronomy (2nd edition), Agrobios (India), Jodhpur
- Reddy, T. Yellamanda and Reddy, G.H. Sankara. 2016. Principles of Agronomy (2nd edition) , Kalyani Publishers, Ludhiana

- Reddy, S.R.2012. Principles of Crop Production (4th edition), Kalyani Publishers, Ludhiana.
- Gupta , O.P. 2005. Weed Management: Principles and Practices (2nd Ed) Agribios (India) Jodhpur.
- Mishra, R.D. and Ahmed, M. 1987. Manual on Irrigation Agronomy, Oxford & IBH Publishing Co. Pvt. Ltd., New-Delhi.
- राजपूत, आर.एल. एवं त्रिपाठी, एम.एल. (2009). खरपतवार प्रबंधन, कुाल पब्लिकेान, वाराणसी
- पोरवाल, बी. एल., सिंह, पुष्पेन्द्र एवम् शर्मा, डी. डी. 2000. सस्य विज्ञान के मूल तत्व, के. पी. प्रकाशन, उदयपुर

2. AGR – 112 (Agriculture Heritage)

Credit Hours: 1 (1+0)

Topics in Theory:

S. No.	Topics
1.	Introduction of Indian agricultural heritage
2.	Ancient agricultural practices,
3.	Relevance of heritage to present day agriculture
4.	Past and present status of agriculture and farmers in society
5.	Journey of Indian agriculture and its development from past to modern era;
6.	Plant production and protection through indigenous traditional knowledge;
7.	Crop voyage in India and world;
8.	Agriculture -scope; Importance of agriculture and agricultural resources available in India;
9.	Crop significance and classifications;
10.	Classification of crops-botanical, agronomic, seasonal.
11.	Classification of crops based on life span, special purposes i.e. cover, green manure, catch, trap, cash, soiling.
12.	National agriculture setup in India;
13.	Current scenario of Indian agriculture;
14.	Indian agricultural concerns and future prospects.

Suggested Readings:

- ICAR. 2010. Handbook of Agriculture (6th edition), Indian Council of Agricultural Research, New Delhi.
- Nene, Y.L. 2007. Glimpses of the Agricultural Heritage of India. Asian Agri- History Foundation, Secunderabad, Andhra Pradesh.
- Nene, Y.L., Saxena, R.C. and Choudhary, S.L. 2009. A Textbook on Ancient History of Indian Agriculture, Munshiram Manoharial Publishers Pvt. Ltd,
- Nene, Y.L., Choudhary, S.L. and Saxena, R.C. 2010. Textbook on Ancient History of Indian Agriculture, Asian Agri-History Foundation.
- D. Kumari, Manimuthu Veeral. 2014. Text Book on Agricultural Heritage of India. Agrotech Publishing Academy.

➢ ICAR. Introductory Agriculture. ICAR e-course. Indian Council of Agricultural Research, New Delhi. (http://www.agrimoon.com/wp-content/uploads/Introductory-Agriculture.pdf)

3. AGR – 211[Crop Production Technology-I (Kharif Crops)]

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Rice- Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
2.	Maize-Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
3.	Sorghum-Origin, geographical distribution, economic importance, soil & climatic requirements, varieties, cultural practices & yield (Seed &forage)
4.	Pearl millet & finger millet - Origin, geographical distribution, economic importance, soil and climatic requirements
5.	Pearl millet & finger millet - varieties, cultural practices and yield
6.	Pigeon pea -Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
7.	Groundnut -Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
8.	Urd bean, moong bean package of practices
9.	Soybean-Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
10.	Cotton -Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
11.	Cluster bean, Moth bean, Cowpea and Horse gram package of practices
12.	Sesame, Castor, package of practices
13.	Napier, minor millets, package of practices
14.	Acquaintance about *Panicum*, *Lasiuras and Cenchrus* sunhemp and Jute

Topics in Practical:

S. No.	Topics
1.	Identification of seeds, crops and other inputs of kharif season
2.	Sowing methods of different *kharif* crops
3.	Seed bed preparation of *kharif* crops including rice nursery and transplanting
4.	Working out seed rate, real value, seed size, depth and germination related numerical
5.	Seed treatment and preparation of seed material for sowing
6.	Preparation of seed material for planting of grasses
7.	Fertilizer application in crops, including top dressing and foliar feeding
8.	Identification of weeds in *kharif* season crops

9.	Morphological description of *kharif* season crops
10.	Irrigation operation in various crops, Judging physiological maturity in standing crops
11.	Cotton seed treatment, Effect of seed size on germination and seedling vigour
12.	Yield attributes and calculation on theoretical yield and harvest index
13.	Study of crop varieties and important agronomic and forage experiments at farm
14.	Visit of experiments at farm/research centres of related crops

Suggested Readings:

- Singh, Chhidda, Singh, Prem and Singh, Rajbir. 2003. Modern Techniques of Raising Field Crops, Oxford & IBH Publishing Co., New Delhi.
- Singh, S.S. and Singh, Rajesh. 2013. Crop Management Under Irrigated and Rainfed Conditions. Kalyani Publishers, New Delhi.
- Singh, S.S. and Singh, Rajesh. 2015. Principles and Practices of Agronomy (5th Re-set), Kalyani Publishers, New Delhi, Kalyani Publishers, Ludhiana.
- Prasad, Rajendra. 2002. Text Book of Field Crops Production, ICAR, New Delhi.
- ICAR. 2010. Handbook of Agriculture (6th edition), Indian Council of Agricultural Research, New Delhi
- Reddy, S.R. 2012. Agronomy of Field Crops. Kalyani Publishers, Ludhiana.
- आर्य, आ.एल. एवं आर्य, केशव- 2016- खरीफ सस्य उत्पादन, कल्यानी पब्लिशर्स, लुधियाना
- शक्तावत, मोहन सिंह एवं व्यास, अभय कुमार- 2000. वैज्ञानिक फसल प्रबन्धन, यश पब्लिशिंग हाउस, बीकानेर

4. AGR – 221 [Crop Production Technology-II (Rabi Crops)]

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Wheat- Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
2.	Barley& Oat - Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
3.	Rapeseed, mustard& Taramira - Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
4.	Sunflower& safflower - Origin, geographical distribution, economic importance, soil & climatic requirements, varieties, cultural practices & yield
5.	Chickpea-Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
6.	Lentil- Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
7.	Peas- Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
8.	Sugarcane- Origin, geographical distribution, economic importance, soil and climatic requirements varieties, cultural practices and yield

9.	Lucerne – Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield
10.	Berseem - package of practices
11.	Sugarbeet, Opium poppy- package of practices
12.	Linseed- - package of practices
13.	Medicinal and aromatic crops-mentha, lemon grass and citronella

Topics in Practical:

S. No.	Topics
1.	Identification of seeds, crops and other inputs of *rabi* season
2.	Identification of weeds in *rabi* season crops
3.	Seed rate and related numericals, sowing of wheat and planting of sugarcane.
4.	Fertilizer application in crops and related numerical, application of herbicides and related numericals,
5.	Judging physiological maturity of various crops
6.	Morphological difference in wheat, barley and oat, rapeseed and mustard, berseem and lucerne.
7.	Judging sugarcane maturity based on brix ratio and related calculation
8.	Yield attributing characters, Theoretical yield and related numerical
9.	Crop harvesting and related numericals on harvest index.
10.	Working out seed index (test weight) and cost of cultivation.
11.	Oil extraction of oilseed crops
12.	Study of rabi forage experiments
13.	Study of important agronomic experiments of rabi crops at experimental farms
14.	Visit to research stations of related crops

Suggested Readings:

- Singh, Chhidda, Singh, Prem and Singh, Rajbir. 2003. Modern Techniques of Raising Field Crops, Oxford & IBH Publishing Co., New Delhi.
- Singh, S.S. and Singh, Rajesh. 2013. Crop Management Under Irrigated and Rainfed Conditions. Kalyani Publishers, New Delhi.
- Singh, S.S. and Singh, Rajesh. 2015. Principles and Practices of Agronomy (5th Re-set), Kalyani Publishers, New Delhi, Kalyani Publishers, Ludhiana.
- Prasad, Rajendra. 2002. Text Book of Field Crops Production, ICAR, New Delhi.
- ICAR. 2010. Handbook of Agriculture (6th edition), Indian Council of Agricultural Research, New Delhi
- Reddy, S.R. 2012. Agronomy of Field Crops. Kalyani Publishers, Ludhiana.
- आर्य, आण्एल एवं आर्य, केशव- 2016- खरीफ सस्य उत्पादन, कल्यानी पब्लिशर्स, लुधियाना
- शक्तावत, मोहन सिंह एवं व्यास, अभय कुमार- 2000. वैज्ञानिक फसल प्रबन्धन, यश पब्लिशिंग हाउस, बीकानेर

5. AGR – 222 (Farming Systems and Sustainable Agriculture)

Credit Hours: 1 (1+0)

Topics in Theory:

S. No.	Topics
1.	Farming System-scope, importance, and concept
2.	Types and systems of farming system and factors affecting types of farming
3.	Farming system components and their maintenance,
4.	Cropping system and pattern, multiple cropping system, Efficient cropping system and their evaluation
5.	Allied enterprises and their importance, Tools for determining production and efficiencies in cropping and farming system
6.	Sustainable agriculture-problems and its impact on agriculture indicators of sustainability, adaptation and mitigation,
7.	Conservation agriculture strategies in agriculture
8.	LEIA (Low external input agriculture), LEISA, HEIA (High external input agriculture)
9.	Integrated farming system-historical background, objectives & characteristics, components of IFS and its advantages,
10.	Site specific development of IFS model for different agro-climatic zones, resource use efficiency and optimization techniques,
11.	Resource cycling and flow of energy in different farming system,
12.	Farming system and environment, Visit of IFS model in different agro-climatic zones of nearby states University/ institutes and farmer's field.

Suggested Readings:

- Panda, S.C. (2004). Cropping Systems and Farming Systems, Agrobios (India), Jodhpur.
- Sharma, Arun K. 2002. A Handbook of Organic Farming, Agrobios (India) Ltd., Jodhpur
- Balasubramaniyan, P. and Palaniappan, S.P.2016. Principles and Practices of Agronomy (II Edition), Agrobios (India), Jodhpur.
- Shukla, Rajeev K. 2004. Sustainable Agriculture, Surbhee Publications, Jaipur
- Palaniappan, S.P.1985. Cropping Systems in the Tropics: Principles and Management, Wiley Easter Ltd. and TNAU, Coimbatore.
- Reddy S. R. 2016. Principles of Agronomy (5th edition), Kalyani Publishers, Ludhiana.
- गौतम, आर.सी. एवं सिंह, पंजाब. 1997. टिकाउ खेती, भारतीय कृषि अनुसन्धान परिषद, नई दिल्ली.

6. AGR – 223 (Introductory Agro-meteorology & Climate Change)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Meaning and scope of agricultural meteorology
2.	Earth's atmosphere- its composition, extent and structure, Atmospheric weather

	variables; Atmospheric pressure, its variation with height, Wind, types of wind, daily and seasonal variation of wind speed
3.	Cyclone, anticyclone, land breeze and sea breeze
4.	Nature and properties of solar radiation, solar constant, depletion of solar radiation, Short wave, long wave and thermal radiation, net radiation, albedo
5.	Atmospheric temperature, temperature inversion, lapse rate, Daily and seasonal variations of temperature, vertical profile of temperature,
6.	Energy balance of earth; Atmospheric humidity, concept of saturation, vapour pressure,
7.	Process of condensation, formation of dew, fog, mist, frost, cloud
8.	Precipitation- process, types such as rain, snow, sleet, and hail
9.	Cloud formation and classification; Artificial rainmaking, Monsoon-mechanism and importance in Indian agriculture
10.	Weather hazards - drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold-wave
11.	Agriculture and weather relations; Modifications of crop microclimate, climatic normal for crop and livestock production
12.	Weather forecasting- types of weather forecast and their uses Climate change, climatic variability, global warming, Causes of Climate Change and its impact on regional and national Agriculture.

Topics in Practical:

S. No.	Topics
1.	Visit of Agro-meteorological Observatory, site selection of observatory, exposure of instruments and weather data recording.
2.	Measurement of total, shortwave and long wave radiation, and its estimation using Planck's intensity law.
3.	Measurement of albedo and sunshine duration, computation of Radiation Intensity using BSS.
4.	Measurement of maximum and minimum air temperatures, its tabulation, trend and variation analysis.
5.	Measurement of soil temperature and computation of soil heat flux.
6.	Determination of vapor pressure and relative humidity.
7.	Determination of dew point temperature.
8.	Measurement of atmospheric pressure and analysis of atmospheric conditions.
9.	Measurement of wind speed and wind direction, preparation of wind rose.
10.	Measurement, tabulation and analysis of rain.
11.	Measurement of open pan evaporation and evapo-transpiration.
12.	Computation of PET and AET.

Suggested Readings:

- Sacheti, A.K. 1985. Agricultural Meteorological Instructional Cum Practical Manual (Ed.)

NCERT Publication, New Delhi.

- Lal, D.S. 2005 Climatology, Sharda Pustak Bhawan, Allahabad.
- Varshneya, M.C. and Balakrishna, Pillai, 2003. Text book of Agricultural Meteorology. ICAR, New-Delhi.
- Sahu, D.D., 2007. Agrometeorology and Remote sensing: Principles and Practices , Agrobios (India) , Jodhpur.
- Murithy, K. and Radha, V. 1995. Practical Manual on Agricultural Meteorology , Kalyani Publishers, New-Delhi
- Ghadekar, S.R. (2002 fourth edition). Practical meteorology, Agromet publishers Nagpur (M.S.)
- धीमान, आर.पी.एस. कृशि मौसम एवं जलवायु विज्ञान, रामा पब्लिगि हाउस, मेरठ
- राजपूत, ओ.पी. एवं सिंह राजवीर, (2008). कृशि मौसम विज्ञान एवं जलवायु विज्ञान के सिद्धांत, कुाल पब्लिकेान, वाराणसी

7. AGR – 311 [Practical Crop Production-I (Kharif Crops)]

Credit Hours: 2 (0+2)

Topics in Theory:

S. No.	Topics
1.	Introduction of the course, crop planning and allotment of field
2.	Field preparation, application of manures and fertilizers
3.	Selection of crop and varieties, seed treatment and sowing
4.	Sowing of crops.
5.	Observation of germination
6.	Thinning and gap filling
7.	Intercultural operations-hoeing and weeding
8.	Water management- application of irrigation water and demonstrating methods of irrigation
9.	Top dressing of fertilizer (urea).
10.	Insect and pest management (control)- application of insecticides
11.	Disease management (control)- application of fungicides
12.	Harvesting
13.	Threshing, winnowing and storage
14.	Marketing of produce

Suggested Readings:

- Yawalkar, K.S.; Agarwal, J.P. and Bokde, S. 2008. Manures and Fertilizers (10th edition), Agri-Horticultural Publishing House, Nagpur.
- Balasubramaniyan, P. and Palaniappan, S.P. 2016. Principles and Practices of Agronomy Agrobios (India), Jodhpur.
- Reddy, S. R., 2016. Principles of Agronomy (5th edition), Kalyani Publishers, Ludhiana.
- Singh, S.S. and Singh, Rajesh. 2015. Principles and Practices of Agronomy (5th Re-set), Kalyani Publishers, New Delhi, Kalyani Publishers, Ludhiana.

8. AGR-312 Geo-informatics and Nano-technology for Precision Farming

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Precision agriculture: concepts and techniques; their issues and concernsfor Indian agriculture;
2.	Geo-informatics definition, concepts, tool and techniques; their use in Precision Agriculture
3.	Crop discrimination and Yield monitoring, soil mapping;
4.	Fertilizer recommendation using geospatial technologies; Spatial data and their management in GIS;
5.	Remote sensing concepts and application in agriculture;
6.	Image processing and interpretation;
7.	Global positioning system (GPS), components and its functions;
8.	Introduction to crop Simulation Models and their uses for optimization of Agricultural Inputs
9.	STCR approach for precision agriculture;
10.	Nanotechnology, definition, concepts and techniques,
11.	Brief introduction about nanoscale effects,
12.	Nano-particles, nano-pesticides, nano-fertilizers, nano-sensors,
13.	Use of nanotechnology in seed and water for scaling-up farm productivity
14.	Use of nanotechnology in fertilizer and plant protection for scaling-up farm productivity

Topics in Practical:

S. No.	Topics
1.	Introduction to GIS software, spatial data creation and editing.
2.	Introduction to image processing software. Visual and digital interpretation of remote sensing images.
3.	Generation of spectral profiles of different objects.
4.	Supervised and unsupervised classification and acreage estimation.
5.	Multispectral remote sensing for soil mapping.
6.	Creation of thematic layers of soil fertility based on GIS.
7.	Creation of productivity and management zones
8.	Fertilizers recommendations based of VRT and STCR techniques.
9.	Crop stress (biotic/abiotic) monitoring using geospatial technology.
10.	Use of GPS for agricultural survey.
11.	Formulation, characterization and applications of nanoparticles in agriculture
12.	Projects formulation and execution related to precision farming

Suggested Readings:

- Krishna, K.K. 2013. Precision Farming: Soil Fertility and Productivity Aspects. Apple Academic Press
- Srivastava, G.S. 2014. An Introduction to Geoinformatics. McGrew Hill Education (India) Pvt. Ltd. , New Delhi
- Gupta, R.K. and Subhash Chander. 2008. Principles of Geoinformatics. Jain Brothers, New Delhi.
- Choudhary, S. 2011. Applied Nanotechnology in Agriculture. Arise Publishers & Distributors
- Sekhon, B.S. 2014. Nanotechnology in agri-food production: an overview. Nanotechnology, Science and Applications **7**:31-532.

9. AGR – 321 [Practical Crop Production-II (Rabi Crops)]

Credit Hours: 2 (0+2)

Topics in Theory:

S. No.	Topics
1.	Allotment of land and field preparation
2.	Sowing methods, selection of crops, varieties and seed treatment
3.	Preparation of seed bed and sowing of crops
4.	Thinning and gap filling
5.	Fertilizer application including top dressing of fertilizers
6.	Intercultural operations- hoeing and weeding
7.	Application of moisture conservation practices
8.	Insect and pest management /control – application of insecticides.
9.	Disease management/control –application of fungicides
10.	Harvesting of the crops
11.	Threshing, winnowing and storage
12.	Marketing of produce
13.	Preparation of balance sheet including cost of cultivation and net return per student as well as team of a group of students.

Suggested Readings:

- Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 2008. Manures and Fertilizers (10th edition), Agri-Horticultural Publishing House, Nagpur.
- Balasubramaniyan, P. and Palaniappan, S.P.2016. Principles and Practices of Agronomy (2nd edition), Agrobios (India), Jodhpur.
- Reddy, S. R. 2016. Principles of Agronomy (5th edition), Kalyani Publishers, Ludhiana.
- Singh, S.S. and Singh, Rajesh. 2015. Principles and Practices of Agronomy (5th Re-set), Kalyani Publishers, New Delhi, Kalyani Publishers, Ludhiana.

10. AGR – 322 (Principles of Organic Farming)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Organic farming, principles and its scope in India;
2.	Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture;
3.	Organic ecosystem and their concepts;
4.	Organic nutrient resources and its fortification;
5.	Restrictions to nutrient use in organic farming;
6.	Choice of crops and varieties in organic farming;
7.	Fundamentals of insect, pest, disease mgt
8.	Weed management under organic mode of production;
9.	Operational structure of NPOP
10.	Certification process and standards of organic farming;
11.	Processing, levelling, economic considerations and viability,
12.	Marketing and export potential of organic products

Topics in Practical:

S. No.	Topics
1.	Visit of organic farms to study the various components and their utilization;
2.	Preparation of enrich compost,
3.	Vermicompost,
4.	Bio-fertilizers/bio-inoculants and their quality analysis;
5.	Indigenous technology knowledge (ITK) for nutrient, insect, pest disease and weed management;
6.	Cost of organic production system;
7.	Post-harvest management;
8.	Quality aspect, grading, packaging and handling.

Suggested Readings:

- Dhama, A.K. 2014. Organic Farming for Sustainable Agriculture (2nd edition), Agrobios (India), Jodhpur.
- Sharma, Arun K. 2013. A Handbook of Organic Farming, Agrobios (India), Jodhpur
- Palaniappan, S.P. and Anandurai, K.1999. Organic Farming – Theory and Practice. Scientific Pub. Jodhpur
- Thapa, U and Tripathy, P. 2006. Organic Farming in India, Problems and prospects, Agrtech, Publising Academy, Udaipur.
- शर्मा, अरूण के. 2015. जैविक खेती – नई दिशाए, एग्रोबायोस (इण्डिया), जोधपुर

11. AGR – 323 (Rainfed Agriculture and Watershed Management)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Rainfed agriculture- definition, history and its importance in India with particular to references Rajasthan
2.	Problems of dryland agriculture related to climate, soil, technological and socio economic conditions
3.	Soil and water conservation techniques, Drought: types,
4.	Effect of water deficit on physio-morphological characteristics of the plants,
5.	Use of antitranspirants-their kind, mode of action and effect on crop yield.
6.	Crop adaptation and mitigation to drought;
7.	Water harvesting: importance, its techniques,
8.	Efficient utilization of water through soil and crop management practices,
9.	Water harvesting techniques in dry farming areas
10.	Watershed management- concept, definition, objectives and principles
11.	Integrated watershed management for drylands, a study of model watershed area
12.	Management of crops in rainfed areas,
13.	Contingent crop planning for aberrant weather conditions,
14.	Alternate cropping and land use strategies for dryland agriculture

Topics in Practical:

S. No.	Topics
1.	Studies on climate classification, studies on rainfall pattern in rainfed areas of the country and pattern of onset and withdrawal of monsoons.
2.	Studies on cropping pattern of different rainfed areas in the country and demarcation of rainfed area on map of India.
3.	Interpretation of meteorological data and scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops.
4.	Critical analysis of rainfall and estimation of moisture index and aridity index and possible drought period in the country
5.	Field demonstration on construction of water harvesting structures, effective rainfall and its calculation.
6.	Studies on cultural practices for mitigating moisture stress.
7.	Spray of antitranspirants on dryland crops and their effect on crops
8.	Characterization and delineation of model watershed
9.	Field demonstration on soil & moisture conservation measures
10.	Crops and cropping systems for drylands
11.	Acquiring skill in tillage methods for *in-situ* moisture conservation

12.	Mulching and its effects on soil moistures conservation
13.	Seed soaking, seed treatment with chemicals for sowing in dryland areas
14.	Visit to rainfed research station/watershed**.**

Suggested Readings:

- Jayanthi, C. and Kalpana, R. 2016. Dryland Agriculture, Kalyani Publishers, Ludhiana.
- Reddy, S.R. and Reddy, G. Prabhakara. 2015. Dryland Agriculture, Kalyani Publishers, Ludhiana.
- Murthy, J. V. S. 1994. Watershed Management, Wiley Eastern Limited. New Age International Limited, New Delhi.
- Dhruva Narayan, V.V. Singh, P.P., Bhardwaj, S.P., U. Sharma, Sikha, A.K., Vital, K.P.R. and Das, S.K. 1987. Watershed Management for Drought Mitigation, ICAR, New Delhi.
- Singh, R.P., Sharma, S., Padmanabhan, N.V. , Das, S.K. and Mishra, P.K. 1990.A Field Manual on Watershed Management, ICAR (CRIDA), Hyderabad.
- Singh, P.K. 2000. Watershed Management (Design & Practices), e-media Publication, Udaipur, India.
- Singh, R.P. 1995, Sustainable Development of Dryland Agriculture in India. Scientific Publishers, Jodhpur.

12. AGR – 324 (Weed management)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to weeds
2.	Characteristics of weeds
3.	Harmful and beneficial effects of weeds on ecosystem
4.	Classification of weeds
5.	Reproduction and dissemination of weeds
6.	Dormancy in weeds and its types
7.	Crop-weed competition
8.	Principles of weed management- an introduction
9.	Physical and cultural methods of weed control
10.	Chemical and biological methods of weed control
11.	Herbicide classification
12.	Herbicide active ingredient and formulations
13.	Herbicide application- types and techniques
14.	Introduction to mode of action of herbicides
15.	Herbicidal selectivity to plants
16.	Fate of herbicides

17.	Concept of adjuvant- surfactant, stabilizing agents, stickers, activators and compatibility agents and solvents
18.	Bio-herbicides and their application in agriculture.
19.	Concept of herbicide mixture and utility in agriculture.
20.	Herbicide compatibility with agro-chemicals and their application.
21.	Allelopathy and its application for weed management.
22.	Integrated weed management - An introduction
23.	Integration of herbicides with non chemical methods of weed management.
24.	Weed management in rice, wheat, barley, maize, sorghum and bajra
25.	Weed management in oil seeds and pulses – groundnut, soybean, mustard, gram, lentil, mungbean and urdbean
26.	Aquatic weeds and their management

Topics in Practical:

S. No.	Topics
1.	Identification of weeds and techniques of weed preservation
2.	Collection of common *kharif/rabi* weeds and their preservation
3.	Collection of common perennial weeds and their preservation
4.	Biology of important weeds.
5.	Study of herbicide formulations and mixture of herbicide.
6.	Herbicide and agro-chemicals study.
7.	Shift of weed flora study in long term experiments.
8.	Study of methods of herbicide application,
9.	To become familiar with herbicide spray equipments.
10.	Calibration of herbicide spray equipments
11.	Calculation on herbicidal requirement for field crops and Aquatic situations
12.	Application of pre plant , pre-emergence and post emergence herbicides in the field.
13.	Calculations of weed control efficiency and weed index.
14.	Farm visit to problem areas of weeds

Suggested Readings:

- Saraswat, V.N., Bhan, V.M. and Yaduraju, N.T. 2003. Weed Management , ICAR, New-Delhi.
- Gupta, O.P. 2015. Weed Management: Principles and Practices (2nd Ed.), Agribios (India), Jodhpur.
- Gupta, O.P. 2016. Modern Weed Management , Agribios (India), Jodhpur
- Das, T.K. 2008. Weed Science : Basics and Applications , Jain Brothers, New-Delhi.
- Rao, V.S. 2000. Principals of Weed Science (2nd edition), Oxford and IBH Publishing Co., New Delhi.
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Department – Agricultural Economics and Farm Management

13. AEC – 121 (Fundamentals of Agricultural Economics)

Credit Hours: 2 (2+0)

Topics in Theory:

S. No.	Topics
1.	Economics: Meaning, scope and subject matter
2.	Definitions, activities, Approaches to economic analysis; Micro and macro economics, positive and normative analysis
3.	Nature of economic theory; rationality assumption
4.	Concept of equilibrium
5.	Economic laws as generalization of human behavior; Basic concepts: Goods and services, desire, want, demand, utility, cost and price, wealth, capital, income and welfare
6.	Agricultural economics: Meaning, definition, characteristics of agriculture; Importance and its role in economic development
7.	Agricultural planning and development in the country
8.	Demand: Meaning Law of demand, demand schedule and demand curve; Determinants
9.	Utility theory; law of diminishing marginal utility
10.	Equi-marginal utility principle
11.	Consumer's equilibrium and derivation of demand curve, concept of consumer surplus
12.	Elasticity of demand: concept and measurement of price elasticity
13.	Income elasticity and cross elasticity
14.	Production: Process, creation of utility
15.	Factors of production, input output relationship
16.	Laws of returns
17.	Law of variable proportions and law of returns to scale
18.	Cost: Cost concepts, short run and long run cost curves
19.	Supply: Stock v/s supply, law of supply, supply schedule, supply curve
20.	Determinants of supply, elasticity of supply
21.	Basic features of perfectly competitive and imperfect markets. Price determination under perfect competition; short run and long run equilibrium of firm and industry, shut down and break even points.
22.	Distribution theory, Meaning, factor market and pricing of factors of production
23.	Concepts of rent, wage, interest and profit
24.	Population: Importance, Malthusian and Optimum population theories, natural and socio-economic determinants, current policies and programmes on population control. Money: Barter system of exchange and its problems, evolution, meaning and functions of money, classification of money, money supply, general price index, inflation and deflation.
25.	Good and services tax (GST) - meaning, definition, advantage and disadvantages and its

	implication on Indian economy.
26.	Meaning, direct and indirect taxes, agricultural taxation
27.	Agricultural and public finance: meaning, micro v/s macro finance, need for agricultural finance, public revenue and public expenditure.
28.	Functions of Central Banks & commercial Banks in India
29.	VAT. Economic systems: Concepts of economy and its functions, important features of capitalistic, socialistic and mixed economies, elements of economic planning.

Suggested Readings:

- Dominick Salvatore, 2011, Outline of Microeconomics, Schaum's Outline Series.
- Bhavani Devi,P. Raghu Ram, S. Subba Reddy, T.V. Neelakanta Sastry, 2009, Agricultural economics, Oxford and IBH Co. Pvt. Ltd., , New Delhi.
- K. K. Dewett and J. D. Varma, 1986, Elementary Economic Theory, S. Chand & Company, New Delhi.
- Latika Sharma *et al* (2014) Principles of agricultural economics, Agrotech publishers, Udaipur.
- M.L. Jhingan, 2004, Micro Economic Theory, Vikas Publishing

14. AEC – 211 (Agricultural Finance and Co-operation)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Agricultural finance: Meaning, scope and significance,
2.	Credit needs and its role in Indian agriculture.
3.	Agricultural credit: Meaning, definition, need, classification.
4.	Credit analysis- 3 R's, 5 C's and 7 P's, of Credits
5.	Sources of agricultural finance: institutional and non-institutional sources
6.	Commercial banks, social control and nationalization of commercial banks, micro financing including KCC
7.	Lead Bank Scheme, RRBs
8.	Scale of finance and unit cost
9.	An introduction to higher financing institutions – RBI, NABARD, ADB, IMF, World Bank
10.	Crop insurance and its scope
11.	Credit guarantee corporation of India
12.	Pradhan Mantri Fasal Bima Yogana- features, significant and limitation
13.	Cost of credit
14.	Recent development in agricultural credit
15.	Preparation and analysis of financial statements – balance sheet and income statement.
16.	Basic guidelines for preparation of project reports- bank norms – SWOT analysis

17.	Financial instruments and methods – e banking, Kisan Cards and core banking
18.	Agricultural cooperation: Meaning, brief history of cooperative development in India
19.	Objectives, principles of cooperation, significance of cooperatives in Indian agriculture
20.	Agricultural cooperation in India- credit, marketing, consumer and multi-purpose cooperatives, farmers' service cooperative societies, processing cooperatives, farming cooperatives,
21.	Cooperative warehousing; role of ICA, NCUI, NCDC, NAFED

Topics in Practical:

S. No.	Topics
1.	Optimum allocation of limited amount of capital among different enterprise
2.	Analysis of progress and performance of cooperatives using published data
3.	Analysis of progress and performance of commercial banks and RRBs using published data
4.	Visit to a commercial bank, cooperative bank and cooperative society to acquire first-hand knowledge of their management, schemes and procedures.
5.	Estimation of credit requirement of farm business – a case study
6.	Preparation and analysis of balance sheet – a case study
7.	Preparation and analysis of income statement – a case study.
8.	Appraisal of a loan proposal – a case study
9.	Techno-economic parameters for preparation of projects
10.	Preparation of bankable projects for various agricultural products and its value added products.
11.	Different type of repayment plans

Suggested Readings:

- S. Subba Reddy, P. Raghu Ram, 1996, Agricultural finance and management, Oxford & IBH Pub. Co, New Delhi
- Kamat, G.S., 1978, New Dimensions of Cooperative Management, Himalayan Publishing House, Mumbai.
- Nelson and Murray, 1988. Agricultural Finance. Kalyani Publishers, New Delhi.
- Pandey, U.K. 1990. An Introduction to Agricultural Finance, Kalyani Publishers, New Delhi.
- Singh, J.P., 1988, Agricultural Finance Theory and Practices, Ashish Publishing House, New Delhi.
- Muniraj, R. 1987, Farm finance for development, Oxford & IBH Pub. Co., New Delhi.

15. AEC – 221 (Agricultural Marketing, Trade and Prices)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Agricultural marketing: Concepts and definitions of market, marketing, agricultural marketing,
2.	Market structure
3.	Basic features of Perfectly competitive and imperfect market
4.	Price determination under perfect competition
5.	Short run and long run equilibrium of firm & industry; Shut down and break-even point
6.	Marketing mix and market segmentation: Classification and characteristics of agricultural markets
7.	Demand, supply and producer's surplus of agri-commodities: Nature and determinants of demand and supply of farm products
8.	Producer's surplus – meaning and its types, marketable and marketed surplus
9.	Factors affecting marketable surplus of agri-commodities
10.	Product life cycle :PLC and competitive strategies: Meaning and stages in PLC; Characteristics of PLC; strategies in different stages of PLC
11.	Pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing
12.	Market promotion :Advertising, personal selling, Sales promotion and publicity – their meaning and merits & demerits
13.	Marketing process and functions: Marketing process-concentration, dispersion and equalization;
14.	Exchange functions – buying and selling;
15.	Physical functions – storage, transport and processing; Facilitating functions – packaging, branding, grading, quality control and labelling (AGMARK)
16.	Market functionaries and marketing channels
17.	Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products;
18.	Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; Marketing efficiency; marketing costs, margins and price spread;
19.	Factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs;
20.	Role of Govt. In agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP & DMI – their objectives and functions
21.	Cooperative marketing in India
22.	Risk in marketing: Types of risk in marketing Speculation & hedging; an overview of futures trading
23.	Agricultural prices and policy: Meaning and functions of price

24.	Administered prices; need for agricultural price policy
25.	Trade: Concept of International Trade and its need,
26.	Theories of absolute and comparative advantage
27.	Present status and prospects of international trade in agri-commodities; GATT and WTO
28.	Agreement on Agriculture (AoA and its implications on Indian agriculture; IPR

Topics in Practical:

S. No.	Topics
1.	Plotting and study of demand and supply curves and calculation of elasticities**;**
2.	Study of relationship between market arrivals and prices of some selected commodities
3.	Computation of marketable and marketed surplus of important commodities
4.	Study of price behaviour over time for some selected commodities, Construction of index numbers
5.	Price forecasting; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity
6.	Collection of data regarding marketing costs, margins and price spread and presentation of report in the class;
7.	Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. To study their organization and functioning;
8.	Application of principles of comparative advantage of international trade

Suggested Readings:

- S. Subba Reddy, P. Raghu Ram, 1996, Agricultural finance and management, Oxford & IBH Pub. Co, New Delhi
- Kamat, G.S., 1978, New Dimensions of Cooperative Management, Himalayan Publishing House, Mumbai.
- Nelson and Murray, 1988. Agricultural Finance. Kalyani Publishers, New Delhi.
- Pandey, U.K. 1990. An Introduction to Agricultural Finance, Kalyani Publishers, New Delhi.
- Singh, J.P., 1988, Agricultural Finance Theory and Practices, Ashish Publishing House, New Delhi.
- Muniraj, R. 1987, Farm finance for development, Oxford & IBH Pub. Co., New Delhi.

16. AEC – 321 (Farm Management, Production & Resource Economics)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Farm management: Meaning and concept, objectives and relationship with other sciences
2.	Meaning and definition of farms, its types and characteristics, factor determining types and size of farms.
3.	Principles of farm management: concept of production function and its type

4.	Use of production function in decision-making on a farm, factor-product, factor-factor and product-product relationship,
5.	Law of equi-marginal/or principles of opportunity cost and law of comparative advantage
6.	Meaning and concept of cost, types of costs and their interrelationship
7.	Importance of cost in managing farm business and estimation of gross farm income, net farm income, family labour income and farm business income
8.	Farm business analysis: Meaning and concept of farm income and profitability, Technical and economic efficiency measures in crop and livestock enterprises
9.	Importance of farm records and accounts in managing a farm, various types of farm records needed to maintain on farm, Farm inventory, balance sheet, profit and loss accounts
10.	Meaning and importance of farm planning and budgeting, partial and complete budgeting,
11.	Steps in farm planning and budgeting
12.	Linear programming, appraisal of farm resources, selection of crops and livestock's enterprises.
13.	Concept of risk and uncertainty : Concept of risk and uncertainty occurs in agriculture production, Nature and sources of risks and its management strategies
14.	Concepts of resource economics, Differences between NRE and agricultural economics, Unique properties of natural resources
15.	Positive and negative externalities in agriculture, Inefficiency and welfare loss, solutions
16.	Important issues in economics and management of common property resources of land, water, pasture and forest resources etc.

Topics in Practical:

S. No.	Topics
1.	Preparation of farm layout
2.	Determination of cost of fencing of a farm
3.	Computation of depreciation cost of farm assets
4.	Application of equi-marginal returns/opportunity cost principle in allocation of farm resources.
5.	Determination of most profitable level of inputs use in a farm production process
6.	Determination of least cost combination of inputs
7.	Selection of most profitable enterprise combination
8.	Application of cost principles including CACP concepts in the estimation of cost of crop and livestock enterprises.
9.	Preparation of farm plan and budget, farm records and accounts and profit & loss accounts.
10.	Collection and analysis of data on various resources in India

Department – Agricultural Engineering

17. AEG – 121 (Soil and Water Conservation Engineering)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to Soil and Water Conservation causes of soil erosion.
2.	Definition and agents of soil erosion.
3.	Water erosion and its forms -raindrop, sheet, rill and gully erosion.
4.	Gully classification and control measures.
5.	Soil loss estimation by universal Soil Loss Equation.
6.	Principles of water erosion control: Introduction to contouring, strip cropping. Contour bund.
7.	Graded bund and bench terracing.
8.	Grassed waterways and their design.
9.	Water harvesting and its techniques.
10.	Wind erosion- mechanics of wind erosion, types of soil movement.
11.	Principles of wind erosion control and its control measures.

Topics in Practical:

S. No.	Topics
1.	General status of soil conservation in India and Madhya Pradesh.
2.	Calculation of soil erosion index.
3.	Estimation of soil loss.
4.	Measurement of soil loss.
5.	Preparation of contour maps.
6.	Design of grassed waterways.
7.	Design of contour bunds.
8.	Design of graded bunds.
9.	Design of bench terracing system.
10.	Problem on wind erosion.

Suggested Readings:

- Water harvesting and recycling: Indian experience. Sharma and Sikka. Central Soil Water Conservation Research Institute, Dehradun.
- Land and Water Management Engineering. 1982. Murthy V.V.N. Kalyani Publishers, New Delhi.
- Irrigation: Theory and Practices.2012. Michael A.M. Vikas Publishing House Pvt. Ltd., New Delhi.
- Principles of Agricultural. Engineering. Vol. II. 2012. Michael A.M. and T.P. Ojha. Jain Brothers, New Delhi.

➢ Soil and Water Conservation Water Management. 2010. Mahnot, S.C., Singh P.K. and Chaplot, P.C., Apex Publication House, Udaipur.

18. AEG – 211 (Farm Machinery and Power)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Status of Farm Power in India and MP, Sources of Farm Power.
2.	I.C. engines and its components, Working principles of IC engines.
3.	Comparison of two stroke and four stroke cycle engines. I.C. engine terminology and Problem based on it.
4.	Air cleaning system- Pre cleaners, oil soaked type and oil bath type air cleaners; hydraulic control system of a tractor.
5.	Cooling system-thermo siphon system and forced circulation system; fuel supply system of I.C. engines.
6.	Lubricating system- splash system and forced feed system of I.C. engines.
7.	Power transmission system- clutch, gearbox, differential, final drive, and P.T.O. shaft of a tractor.
8.	Tractor types, Cost analysis of tractor power and attached implement.
9.	Familiarization with primary tillage implements- mould board plough, disc plough
10.	Familiarization with secondary tillage implements- cultivators harrows and hoes.
11.	Familiarization with implement for intercultural operations and for hill agriculture.
12.	Familiarization with sowing and planting equipment-seed drill and planters.
13.	Calibration of a seed drill and solved problems based on it.
14.	Familiarization with Plant Protection equipment- sprayer and duster.
15.	Familiarization with harvesting equipment- reaper, mover, combine harvester.
16.	Familiarization with threshing equipment- multi-crop power thresher

Topics in Practical:

S. No.	Topics
1.	To Study of different components of I.C. engine.
2.	To study of air cleaning and fuel supply system of I.C. engine.
3.	Familiarization with transmission system-clutch, gear box, differential, final drive.
4.	Study of cooling and lubrication system of engine.
5.	Familiarization with brake, steering, hydraulic control system of tractor.
6.	Learning of tractor driving.
7.	Familiarization with operation of power tiller and Implements for hill agriculture.
8.	Study of primary tillage implements: mould board plough, disc plough.
9.	Study of secondary tillage implements- cultivators, harrows and hoes.

10.	Familiarization with seed-cum-fertilizer drills their seed metering mechanism.
11.	Calibration of seed drill and numerical based on it.
12.	Study of planters and transplanters.
13.	Familiarization with different types of sprayers and dusters.
14.	Familiarization with different inter-cultivation equipment.
15.	Familiarization with harvesting and threshing machinery.

Suggested Readings:

- Principles of Agricultural Engineering. Vol. I. 2012. Michael, A.M. and T.P. Ojha. Jain Brothers, Jodhpur.
- Farm Tractors, Maintenance and Repair.1989. Rai and Jain. Tata Mc Graw Hill Publ. New Delhi.
- Elements of Farm Machinery.1989. Srivastava, A.C. Oxford IBH Publ. Company, New Delhi.
- Elements of Agricultural Engineering, Vol. I & III. 1989. Singhal, O.P. Suraj Prakashan, Allahabad.
- Element of Agricultural Engineering. 1990. Sahay, Jagdishwar. Agro. Book Agency, New Chitragupta Nagar, Patna.

19. AEG – 221 (Renewable Energy and Green Technology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Classification of energy sources, contribution of these sources in agricultural sector.
2.	Familiarization with biomass utilization for bio fuel production and their application.
3.	Familiarization with different types of biogas plants- fixed dome and floating drum type biogas plants.
4.	Biogas production techniques and various uses of biogas.
5.	Biomass gasification and familiarization with different types of gasifiers-.cross draft, updraft and down draft gasifiers.
6.	Bio alcohol, biodiesel and bio oil production and their utilization as bio energy resource
7.	Introduction of solar energy, their collection and application
8.	Familiarization with solar energy gadgets: solar cooker, solar water heater
9.	Application of solar energy: solar drying, solar pond, solar distillation, solar photovoltaic system and their application
10.	Introduction of wind energy and their application.

Topics in Practical:

S. No.	Topics
1.	To Study of fixed dome and floating drum type biogas plants.
2.	To Study of cross draft, updraft and down draft gasifiers.

3.	To study the production process of biodiesel.
4.	To study briquetting machine.
5.	To study the production process of bio-fuels.
6.	To study solar photovoltaic system: solar light, solar pumping, and solar fencing.
7.	To study solar cooker,
8.	To study solar drying system.
9.	To study solar distillation and solar pond.

Suggested Readings:

- Navinikrat Urja Srot (Hindi) Rathore NS. Himanshu Publications.
- G.D. Rai. Non-Conventional Energy Sources, Khanna Publishers, New Delhi.
- N. S. Rathore. A.K. Kurchania, N.L. Panwar. (2007). Non-Conventional Energy Sources, Himanshu Publications.
- N.S. Rathore. A. K. Kurchania, N.L. Panwar. (2007). Renewable Energy, Theory and Practice, Himanshu Publications.
- K.C. Khandelwal. & S.S. Mandi. (1990). Biogas Technology.

20. AEG – 321 (Protected Cultivation and Secondary Agriculture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to greenhouse technology, types of green houses and Plant response to Greenhouse environment.
2.	Planning and design of greenhouses.
3.	Design criteria of green house for cooling and heating purposes.
4.	Greenhouse equipments, materials of construction for traditional and low cost green houses.
5.	Irrigation systems used in green houses.
6.	Passive solar green house and hot air greenhouse heating systems, greenhouse drying.
7.	Cost estimation and economic analysis of green house.
8.	Important engineering properties such as physical, thermal, aero & hydrodynamic of cereals, pulses and oilseed. Application of these in PHT equipment design and operation.
9.	Drying and dehydration: Moisture measurement, EMC, drying theory, various drying methods.
10.	Commercial grain dryer (deep bed dryer, flat bed dryer, tray dryer, fluidized bed dryer, re-circulatory dryer and solar dryer).
11.	Material handling equipment: conveyers and elevators, their working principle and selection.

Topics in Practical:

S. No.	Topics
1.	Study of different type of green houses based on shape.
2.	Determine the rate of air exchange in an active summer & winter cooling system.
3.	Determination of drying rate of agricultural products inside green house.
4.	Study of greenhouse equipments.
5.	Visit to various Post Harvest Laboratories.
6.	Determination of Moisture content of various grains by oven drying & infrared moisture methods.
7.	Determination of engineering properties (shape and size, bulk density and porosity of biomaterials).
8.	Determination of Moisture content of various grains by moisture meter.
9.	Field visit to seed processing plant.

Suggested Readings:

- Sanrakshit kheti ke antargat satat fasal prabandhan. Rao KVR. Scientific Publication.
- Green house: Science and Technology. 2016. Kothari S, S.C. Kaushik and A.N. Mathur. Himanshu Publication, Udaipur.
- Green House Technology- Application and Practice. Sharma A and V.M. Salokhe. 2006. Agro Tech. publication, Udaipur
- Principles of Agricultural Engineering, Vol. I. 2012. Michael, A.M. and T. P. Ojha . Jain Brothers, New Delhi.
- Post-Harvest Technology of Cereals, Pulses and Oil Seeds.1999. Chakravarty, A. Oxford and IBH Pub. New Delhi.
- Agricultural Process Engineering. 1955. Henderson, S.M. and R.L. Perry. John Willy and Sons, New York.
- Unit operation of Agriculture Processing. 2004. Shay K.M. and Singh, K.K. Vikas Publication House, New Delhi.

Department – Entomology

21. ENT – 121 (Fundamental of Entomology)

Credit Hours: 4 (3+1)

Topics in Theory:

S. No.	Topics
1.	Definition and importance of entomology. History of entomology in India. Factors of insect's abundance.
2.	Phylum Arthropoda- classification up to classes with examples and their relationship with class Insecta
3.	Structure of insect body segmentation – head, thorax & abdomen. Structure & functions of insect cuticle and moulting
4.	Structure & modifications of antennae and mouth-parts.
5.	Structure & functions of legs and wings
6.	Wing venation and wing coupling apparatus
7.	Structure & functions of male and female genital organs
8.	Structure & functions of digestive and circulatory systems.
9.	Structure & functions of excretory and respiratory systems.
10.	Structure & functions of endocrine and reproductive systems. Types of reproduction.
11.	Structure & functions of nervous system. Major sensory organs like simple and compound eyes and chemoreceptors.
12.	Types of metamorphosis, diapause, larvae and pupae.
13.	Definition & importance of insect ecology. Components of environment.
14.	Effect of abiotic factors [temperature, moisture, humidity, rainfall, light, atmospheric pressure and air current].
15.	Effect of biotic factors [food competition, natural & environmental resistance]. Concept of balance of nature
16.	Definitions of biotic potential & causes of outbreak of pests in agro-ecosystem.
17.	Categories of pests; pest surveillance and pest forecasting.
18.	Definition & importance of IPM. Tools of IPM like host plant resistance, cultural and legislative methods [Insecticide Act 1968].
19.	Mechanical, physical and biological methods [parasites, predators and transgenic plant pathogens like bacteria, fungi and viruses].
20.	Chemical control – importance, hazards & limitations. Classification of insecticides.
21.	Toxicity of insecticides. Formulations of chemical insecticides.
22.	Recent methods – repellents, antifeedants, hormones, attractants, gamma radiation and genetic control [definitions with examples].
23.	Practices, scope and constraints of IPM.
24.	Application techniques of spray fluids, phytotoxicity. Precautions in using chemical insecticides. Symptoms of poisoning, first-aid and antidotes.
25.	Systematics & taxonomy – definitions, importance, history and development. Binomial

	nomenclature. Definitions of biotype, sub-species, species, genus, family and order.
26.	Modern scheme of insect classification up to order [According to Gillott, 2005].
27.	Main characters of insect orders of agricultural importance with names of important families including examples – Odonata, Blattaria [Blattidae], Isoptera [Termitidae, Mantodea [Mantidae].
28.	Order Orthoptera [Acrididae, Tettigonidae, Gryllidae, Gryllotalpidae]. Order Thysanoptera [Thripidae].
29.	Order Hemiptera [Pentatomidae, Coreidae, Cimicidae, Pyrrhocoridae, Lygaeidae, Cicadellidae, Delphacidae, Aphididae, Coccidae, Lophopidae, Aleurodidae, Pseudococcidae].
30.	Order Neuroptera [Chrysopidae]. Order Coleoptera [Coccinellidae, Chrysomelidae, Cerambycidae, Curculionidae, Bruchidae, Scarabaeidae.
31.	Order Diptera [Cecidomyiidae, Tachinidae, Agromyziidae, Culicidae, Muscidae, Tephritidae].
32.	Order Lepidoptera [Pieridae, Papilionidae, Noctuidae, Sphingidae, Pyralidae, Gelechiidae, Arctiidae, Saturnidae, Bobmycidae].
33.	Order Hymenoptera [Tenthridinidae, Apidae, Trichogrammatidae, Braconidae, Clacididae].

Topics in Practical:

S. No.	Topics
1.	Methods of collection & preservation of insects including immature stages.
2.	External features of grasshopper.
3.	Types of antennae, mouth-parts and legs.
4.	Types of wings & wing coupling apparatus.
5.	Types of larvae & pupae.
6.	Dissection of digestive system of grasshopper.
7.	Dissection of reproductive system of male & female grasshopper.
8.	Study of major characters of order Orthoptera and Isoptera with the help of grasshopper and Termite, respectively.
9.	Study of major characters of order Blattaria with the help of sample of cockroach.
10.	Study of major characters of order Hemiptera with the help of sample of green stink bug.
11.	Study of major characters of order Lepidoptera with the help of samples any moth and butterfly.
12.	Study of major characters of order Coleoptera with the help of samples of any weevil and beetle.
13.	Study of major characters of order Diptera with the help of samples of House fly
14.	Sampling techniques for estimation of insect pest population and damage.

Suggested Readings:

- Ambrose, D.P. [2004]. The Insects: Structure, function and biodiversity. Kalyani Publishers,

Ludhiana.

- Ambrose, D.P. [2007]. The Insects: Beneficial and Harmful aspects. Kalyani Publishers, Ludhiana.
- Gillott, Cedric [2005]. Entomology [Third Edition] Springer, Dordrecht, Netherlands.
- Kachhwaha, N. [2011]. Principles of entomology basic and applied. AGROBIOS, Jodhpur.
- Mathur, Y.K. and Upadhyay, K.D. [2012]. A textbook of entomology [7th Edition]. Aman Publishing House, Meerut.
- Richards, O.W. and Davies, R.G. [1977]. Imm's general textbook of entomology Tenth Edition Vol. I & II. Chapman & Hall, London.
- Romoser, W.S. and Stoffolann, J.G. [1998]. The science of entomology [Fourth Edition]. McGraw Hill Company, New York.
- Sharma, Sandeep [2013]. Instructional manual on classification of insects. RVSKVV Publication No. 30/2013.
- Shrivastava, K.P. and Dhaliwal, G.S. [2011]. A textbook of applied entomology Vol. II [Third Edition], Kalyani Publishers, Ludhiana.
- Shrivastava, P.D. and Singh, R.P. [1997]. An introduction to entomology. Concept Publishing Company, New Delhi.

22. ENT – 311 (Pests of Crops & Stored Grains and their Management)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Paddy – Grasshopper, *gundhi* bug, hispa
2.	Paddy – Brown plant hopper, Green leaf hopper, White backed plant hopper
3.	Cotton – Aphid, whitefly, red cotton bug, mite
4.	Cotton – Pink boll worm, spotted boll worm, American boll worm.
5.	*Kharif* pulses [Pigeon pea, green gram, black gram] – Pod fly, pod bug, aphid, pod borer [*Meruca*].
6.	Soybean – Girdle beetle, green semilooper, stink bug, Bihar caterpillar.
7.	Sorghum & maize – Shoot fly, stem borer, cob borer [midge, ear head bug]
8.	Sesame and Groundnut – Leaf webber & capsule borer, hawk moth, white grub, red hairy caterpillar.
9.	Wheat and sugarcane – Termite, early shoot borer, top shoot borer, pyrilla.
10.	Chickpea and pea – Gram cut worm, gram pod borer, pea leaf miner, pea pod borer.
11.	Mustard, safflower and sunflower – Mustard aphid, safflower aphid, mustard sawfly, painted bug, and safflower capsule fly.
12.	Linseed, sunhemp and Mesta – Linseed bug fly, sunhemp hairy caterpillar
13.	Causes of deterioration of grains in store and role of physical, mechanical, chemical and biological factors.
14.	Scientific name, systematic position, host range, distribution, identification, nature of

	damage and biology of rice weevil, *khapra beetle* and pulse beetle.
15.	Scientific name, systematic position, host range, distribution, identification, nature of damage and biology of red flour beetle, rice moth, mite and mould.
16.	Scientific name, systematic position, host range, distribution, identification, nature of damage and biology of house mouse, Norway rat, larger bandicoot rat and house sparrow.
17.	Storage structures [traditional, PUSA bin, warehouse] and principles of stored grain management.
18.	Preventive and curative measures of stored grain pests.
19.	Scientific name, systematic position, distribution, host range, identification, nature of damage, biology and management of
20.	Solanaceous vegetables – Shoot & fruit borer of brinjal, potato tuber moth.
21.	Cruciferous and malvaceous vegetables – Diamond back moth, shoot & fruit borer of okra, okra jassid.
22.	Cucurbits – Red pumpkin beetle, fruit fly
23.	Tomato, chilies, and sweet potato – Tomato fruit borer, chilly thrip, chilly bud fly, sweet potato weevil.
24.	Mango and Guava – Mango leaf hopper, mango mealy bug, mango stone weevil and guava bark eating caterpillar.
25.	Anar and citrus – Anar butterfly, lemon butterfly, citrus psylla, fruit sucking moth.
26.	Grapevine and banana – Vine borer, vine girdler, banana aphid and banana rhizome borer.
27.	Apple and ber – Apple wooly aphid, San Jose scale, ber fruit fly and ber mealy bug.
28.	Coffee and tea – Coffee mealy bug, coffee green plant bug, tea aphid and tea jassid.
29.	Coconut and cashew nut - Rhinoceros beetle, nut borer, cashew nut shoot borer and cashew nut inflorescence caterpillar.
30.	Rose, chrysanthemum and marigold – Rose scale, aphid, and marigold leaf miner.
31.	Tobacco – Tobacco caterpillar, cut worm and gram pod borer.
32.	Turmeric, pepper and coriander – Banana lacewing, Pollu beetle, coriander aphid.
33.	Onion, garlic, ginger and beetle vine – Thrips, ginger fly maggot, and beetle vine scale.

Topics in Practical:

S. No.	Topics
1.	Identification of rice weevil and pulse beetle.
2.	Structure of different storage structures of your locality.
3.	Visit to warehouse.
4.	Identification of immature and mature stages of crop pests and their damaging symptoms – Rice, sorghum, sugarcane, cotton, pulses, potato, tomato, cucurbits, chilli, ginger, bhindi anar, citrus, mango, guava, rose and crops of your locality.

Suggested Readings:

- Ambrose, D.P. [2007]. The Insects: Beneficial and Harmful Aspects. Kalyani Publishers, Ludhiana.
- Atwal, A.S. and Dhaliwal, G.S. [2002]. Agricultural Pests of South Asia and Their Management. Kalyani Publishers, Ludhiana.
- Awasthi, V.B. [2007]. Agricultural Insect Pests and Their Control. Scientific Publishers (India), Jodhpur.
- Dhaliwal, G.S. [2008]. An Outline of Entomology. Kalyani Publishers, Ludhiana.
- Hill, D.S. [1993]. Agricultural Insect Pests of the Tropics and Their Control. Cambridge University Press, Cambridge.
- Kachhwaha, N. [2011]. Principles of entomology basic and applied. AGROBIOS, Jodhpur.
- Mathur, Y.K. and Upadhyay, K.D. [2012]. A textbook of entomology [7th Edition]. Aman Publishing House, Meerut.
- Sharma, Sandeep and Choudhary, Arun [2007]. Storage Pests Management. Mahamaya Publishers, New Delhi.
- Sharma, Sandeep [2013]. Instructional manual on Pests of Field Crops. RVSKVV Publication No. 29/2013.
- Shrivastava, K.P. and Dhaliwal, G.S. [2011]. A Textbook of Applied Entomology Vol. II (Third Edition). Kalyani Publishers, Ludhiana.

23. ENT – 321 (Management of Beneficial Insects)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance of beneficial insects. Beekeeping, various species of honey bees, bee biology and different castes of bees in bee colony.
2.	Bee keeping equipments, bee hives, commercial method of bee rearing.
3.	Seasonal management of bee colony, management for pollination, honey production, swarm control, absconding, summer and rainy season, before and after migration of bee colony and queen management.
4.	Bee pasturage, bee pollinating plants, bee foraging and communication skill in honey bees.
5.	Natural enemies of bees and their management.
6.	Importance of sericulture, types of silk worms, host plants and type of silk produced by them.
7.	Voltinism in silk worm, factors induce voltinism, biology of silk worm.
8.	Varieties of mulberry, mulberry cultivation, methods of harvesting and preservation of mulberry leaves.
9.	Rearing equipments and rearing techniques of silk worm, mounting, harvesting of cocoon and reeling.
10.	Natural enemies of silk worm and their management.
11.	Importance of lac culture, uses of lac, species of lac insects and their morphology.

	Biology and host plants of lac insects.
12.	Production techniques of lac, types of lac, i.e., seed lac, button lac and shellac flacks. Natural enemies of lac insect and their management.
13.	Identification of major insect parasitoids and predators commonly being used in biological control.
14.	Mass multiplication techniques of major parasitoids and predators.

Topics in Practical:

S. No.	Topics
1.	Identification of various bee species and castes. Identification of natural enemies of honey bees.
2.	Handling of bee keeping equipments, bee foraging and communication.
3.	Practical knowledge of seasonal management of bee colony.
4.	Types of silk worms and its biology.
5.	Familiarization with mulberry varieties, cultivation [Moriculture], harvesting of leaves and preservation.
6.	Identification of lac insect and their host plants.
7.	Identification of various insect pollinators, weed killers and scavangers.
8.	Visit to research and training centers of apiculture, sericulture, lac culture and biological control.
9.	Identification of technique for

Suggested Readings:

- Atwal, A.S. [2000]. Essentials of bee keeping and pollination. Kalyani Publishers, Ludhiyana.
- Devid, B.V. and Ananthakrishnan, T.N. [2004]. General and Applied Entomology. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Gillot, Cedric [2005]. Entomology [Third Edition]. Springer, Dordrecht, Netherlands.

Department – Agricultural Extension and Communication

24. EXT – 111 (Rural Sociology and Educational Psychology)

Credit Hours: 2 (2+0)

Topics in Theory:

S. No.	Topics
1.	Sociology: Meaning, definition, scope, importance in agriculture.
2.	Rural sociology: Meaning, definition, scope and importance of rural sociology in extension education.
3.	Society: Meaning & definition of society. Difference between rural and urban society, important characteristics of Indian rural society.
4.	Social group: Definition, meaning & types of social group, role of social group in agricultural extension and characteristic of groups.
5.	Social stratification: Meaning, definition, function, types: class and caste.
6.	Culture: Definition, meaning, classification of culture: material and non-material culture, characteristics, function & role of culture in extension, types of customs: folkways, mores, taboos and rituals, cultural lag, culture trait, culture complex, culture pattern, ethnocentrism, xenocentrism, tempocentrism.
7.	Social institution: Definition, meanings, and types of institution: political, education, economic, family and religion function of institution.
8.	Social change and development: Meaning, definition, factors affecting of social change, nature, dimension of social change.
9.	Educational psychology: Definition, meaning, scope, importance in agricultural extension.
10.	Behavior: Definition and types of behavior: Cognitive, affective, psychomotor domain.
11.	Personality: Definition, meaning, types and factors affecting of personality.
12.	Learning: Definition of learning and learning experience, elements of learning situation, principles of learning.
13.	Motivation: Definition, meaning, types, Maslow's need hierarchy theory of motivation.
14.	Intelligence: Definition, meaning, factors affecting of intelligence, measuring general intelligence.

Suggested Readings:

- Chitambar, J.B. (1997) Introductory Rural Sociology Willey Eastern Limited, New Delhi.
- Mondal, Sagar and G.L. Ray (2012) Text book on rural development entrepreneurship and communication Skills. Kalyani Publishers, New Delhi.
- Chauhan, M.S., Dangi K.L., Maheshwari Alpana and Mundra, S.N. (2012) Hand book of Rural Sociology Agrotech publishing Academy, Udaipur.
- Ray G.L. (2016) Extension Communication and Management. Kalyani Publishers, New Delhi.
- A.R. Desai (1994) Rural Sociology in India Popular Prakashan,
- Rajendra Kumar Sharma (1997) Rural Sociology Atlantic Publishers & Dist,
- Mangal S.K. (2007) Essentials of Education Psychology

25. EXT – 121 (Fundamentals of Agricultural Extension Education)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Education: Meaning, definition, Types: Formal, Normal, informal
2.	Extension Education: Meaning, definition, scope, process, objective and principle of Extension Education.
3.	Extension Programme Planning: Meaning, definition, objectives, principle and steps in programme development.
4.	Extension System in India: (A) Pre independence- era: Sriniketan, Marthandam, Firka development scheme, Gurgaon experiment. (B) Post independent- era: Etawah pilot project, Nilokeheri project, Boodhan movement.
5.	Agricultural development programmes launched by ICAR: National demonstration, KVK, LLP, ORP, TOT, NARP, ATIC, NATP, ATMA, NAIP.
6.	New trends in Agriculture Extension: Privatization extension, cyber extension/ e-extension, meaning, definition, tools, advantage & disadvantage of cyber extension, market-led-extension, farmers-led-extension, expert system, Public Private Partnership (PPP).
7.	Rural Development: Concept, Meaning, definition and importance in agricultural extension.
8.	Rural Development Programmes launched by government of India: IADP, IAAP, ICDS, HYVP and IRDP.
9.	Community Development: Concept, meaning, definition, principal physiology of C.D.
10.	Rural Leadership: Concept, definition, types of leader in rural context and characteristics of leader.
11.	Extension Administration: Meaning, concept, principle and functions.
12.	Monitoring and Evaluation: Concept, definition and monitoring & evaluation of extension programmes.
13.	Transfer of technology: Concept, scope and importance.
14.	Extension teaching methods: Meaning, classification according to use and form, media mix strategies.
15.	Agriculture Journalism: Meaning, brief history, types and importance in agriculture.
16.	Diffusion and adoption of innovation: Meaning, definition, concept, elements of diffusion, process and stages of adoption, adopter categories, characteristics of innovation.
17.	Capacity building of extension personnel: Meaning, definition of training, types of training methods: lecture, panel discussion, group discussion, colloquium, syndicate, symposium, seminar, workshop, conference, brain storming, buzz-session and role-playing.

Topics in Practical:

S. No.	Topics

1.	Study of university extension system
2.	Group discussion
3.	Preparation and use of audio visual aids
4.	Preparation of extension literature, leaflet, booklet, folders, pamphlet, news stories and success stories
5.	Development of presentation skill and micro teaching exercise
6.	Visit of village to understand the problem being encountered by the villagers
7.	Study of functioning of DRDA and other development department at district level
8.	A visit to NGO and learning from their experience in rural development
9.	Use of important PRA tools
10.	Use of the mass media for transfer of agricultural technology
11.	A visit to community radio and television studio for understanding the process of programme production
12.	Script writing, writing for print and electronic media
13.	Script preparation for radio and television

Suggested Readings:

- Mondal, Sagar and Ray, G.L. (2012) Text book on rural development entrepreneurship and communication Skills. Kalyani Publishers, New Delhi.
- Supe, S.V. (2014) Integrated extension education. Agrotech Publishing Academy, Udaipur.
- Dahama, O.P and Bhatnagar, O.P. (2009) Fundamentals of Extension Education and communication for development. Oxford IBH Publishing CO. Pvt. Ltd. New Delhi.
- Khan, P.M. and Somani, L.L. (2009) Fundamentals of Extension Education. Agrotech Publishing Academy, Udaipur.
- Ray G.L. (2016) Extension Communication and Management. Kalyani Publishers, New Delhi.
- Van Den Ban, A.W and Hawkins, H.S. (2002) Agricultural Extension. CBS Publishers & Distributors Pvt. LTD., New Delhi.

26. EXT – 122 (Communication Skills and Personality Development)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Communication: Meaning, definition, process and elements of communication forms of communication, barriers of communication & models: Aristotle, Berlo, J.P. Legans and Laswell
2.	Communication skills: meaning, significance, need.
3.	Verbal and non-verbal communication: meaning, definition and kinds.
4.	Listening: meaning, significance of listening and kinds of listener.
5.	Note taking: significance and taking notes.
6.	Writing skills: tools and importance of writing skills

7.	Oral presentation skills: meaning, need, significance and effectiveness.
8.	Field diary and lab records: meaning, purpose, significance and preparation.
9.	Indexing: meaning, importance and preparation, Footnotes: meaning and purpose.
10.	Bibliography: meaning, various format and procedure of bibliography.
11.	Reading and comprehension of general and technical articles.
12.	Precise writing: meaning, concept and effectiveness of precise writing.
13.	Summarizing: definition, purpose and importance of summarizing.
14.	Abstracting: definition, purpose, uses and writing abstract for thesis.
15.	Individual and group presentation: significance, effectiveness, use of audio visual aids and conduct a good presentation.
16.	Impromptu presentation: meaning, scope, use and importance.
17.	Public speaking, group discussion, organizing seminars and conference.

Topics in Practical:

S. No.	Topics
1.	Listening and note taking
2.	Writing skills
3.	Oral presentation skills
4.	Preparation of Field diary and lab records
5.	Indexing, footnote and bibliographic procedures
6.	Reading and comprehension of general
7.	Preparation of Technical articles
8.	Preparation of Precise writing
9.	Summarizing
10.	Abstracting
11.	Individual presentations
12.	Group presentations

Suggested Readings:

- Kalla, P.N., Sharma, S.K., Singh Archana Raj, Rathore Rajendra and Chaudhary Meenakshi (2012) Communication Skills for extension workers. Agrotech Publishing Academy, Udaipur.
- Carey, Harry A. (2007) Communication in extension a teaching and learning guide. Daya Publishing House, New Delhi.
- Mondal, Sagar and Ray, G.L. (2012) Text book on rural development entrepreneurship and communication Skills. Kalyani Publishers, New Delhi.

27. EXT – 311(Entrepreneurship Development and Business Communication)

Credit Hours: 2(1+1)

Topics in Theory:

S. No.	Topics
1.	Entrepreneurship: Concept, meaning, definition, factors responsible for entrepreneurship, assessment of entrepreneurship skill, opportunities for entrepreneurship, rural entrepreneurship.
2.	Entrepreneur: Concept meaning, definition, types of entrepreneur, characteristics of entrepreneur and difference between entrepreneur and manager.
3.	Enterprise: Meaning, definition, management of enterprise.
4.	SWOT analysis: Concept, meaning and use.
5.	Entrepreneurship Development: Phases of entrepreneurship development process: stimulatory phases, Support phases and Sustaining phases.
6.	Entrepreneurial behavior: Definition, concept and dimension: achievement motivation as a dimension entrepreneurial behavior, Gender dimension of entrepreneurial behavior, Leadership as a dimension entrepreneurial behavior.
7.	Achievement motivation: Meaning, concept and factors affecting of achievement motivation.
8.	Government Policy: IPR-1948, IPR-1956, IPR-1977, IPR-1980, IPR-1990, New small enterprise policy 1991, MSMED Act-2006.
9.	Programs and institutions for Entrepreneurship development: National level training institution (NISIET, NIESBUD, IIE, EDDI), Apex national level govt. organization (SIDO), central level infrastructure development organization (NSIC& KVIC), state level entrepreneurship training institutions: institute of entrepreneurship development, center of entrepreneurship and management development.
10.	Business Leadership Skill: Communication skills for entrepreneurship development, developing organizing skill, managerial skill and problem solving skill.
11.	Supply chain management: Meaning, concept, definition, problems and functions of supply chain management.
12.	Entrepreneurship development programme: Meaning, objectives and phases of EDP.
13.	Total quality management, project planning, formulation and report preparation.

Topics in Practical:

S. No.	Topics
1.	Assessment of entrepreneurial potential.
2.	Study of the problem solving ability of entrepreneur.
3.	Study of the managerial skill of entrepreneur.
4.	An exercise in creativity and time audit
5.	Project Preparation
6.	Visit to entrepreneurship development institute and entrepreneurs

7.	Visit to enterprises related to agriculture

Suggested Readings:

- Khanka, S.S. (2013) Entrepreneurial development. S. Chand & Company Pvt. LTD., New Delhi.
- Desai Vasant (2007) Dynamic of Entrepreneurial development & Management. Himalaya Publishing House, Mumbai.
- Grover, Indu (2008) Hand book on empowerment and Entrepreneurship Vinayak book House, Udaipur.
- Mondal, Sagar and Ray, G.L. (2012) Text book on rural development entrepreneurship and communication Skills. Kalyani Publishers, New Delhi.

Department – Genetics and Plant Breeding

28. GPB – 121 (Fundamentals of Genetics)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Pre and Post Mendelian concepts of heredity
2.	Mendelian principles of heredity
3.	Cell division – mitosis &Meiosis
4.	Probability and Chi-square
5.	Dominance relationships and gene interaction
6.	Epistatic gene interactions with examples (complementary, supplementary, duplicate gene interactions)
7.	Epistatic gene interactions with examples (masking, inhibitory, polymeric and additive gene interactions)
8.	Pleiotropism, pseudoalleles, Multiple alleles and Blood group genetics
9.	Sex determination
10.	Sex linkage & Sex limited, sex influenced and sex linked traits
11.	Linkage and its estimation
12.	Crossing over : introduction & mechanisms
13.	Chromosome mapping
14.	Structural changes in chromosome
15.	Numerical changes in chromosome Use of haploids, dihaploids and doubled haploids in Genetics
16.	Mutation: introduction, characteristics & classification
17.	Mutagenic agents: physical and chemical mutagens
18.	Induction of mutation, Methods of inducing mutation & CIB technique
19.	Qualitative & Quantitative traits, Polygenes and continuous variations
20.	Multiple factor hypothesis
21.	Cytoplasmic inheritance
22.	Genetic disorders
23.	Nature, structure and types of genetic material
24.	Proof for DNA as genetic material
25.	Replication of genetic material
26.	Genetic code & Protein synthesis
27.	Transcription mechanism of genetic material
28.	Translational mechanism of genetic material
29.	Gene concept: Gene structure and function
30.	Gene regulation, operon concept, Lac and Trp operons

Topics in Practical:

S. No.	Topics
1.	Study of microscope: parts and types
2.	Study of cell structure
3.	Experiments on monohybrid, test cross and back cross
4.	Experiments on dihybrid, test cross and back cross
5.	Experiments on trihybrid, test cross and back cross
6.	Experiments on epistatic interactions including test cross and back cross
7.	Stains and their preparation
8.	Fixatives and their preparation
9.	Practice on mitotic & Meiotic cell division
10.	Experiments on probability
11.	Experiments on Chi-square test
12.	Determination of linkage and cross over analysis (through two point test cross and three point test cross data)
13.	Study on sex linked inheritance in Drosophila
14.	Study of models on DNA and RNA structure

Suggested Readings:

- Gupta P.K.2004. *Cytology, Genetics and Evolution*. Rastogi Publications, Meerut. (Hindi Edition)
- Klug, W.W. and Cummings, M.R.2005.*Concepts of Genetics.* Pearson Education (Singapore) Pvt. Ltd., Indian Branch, Pratap Ganj, New Delhi.
- Singh, B.D. 2001.*Genetics.* Kalyani
- Strickberger, M.W.2001.*Genetics.* Prentice Hall of India. Pvt. Ltd., New Delhi.

29. GPB – 211 (Fundamentals of Plant Breeding)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Plant breeding: concept, nature, objectives and role of plant breeding
2.	Historical development of plant breeding
3.	Genetics in relation to plant breeding, Major achievements and future prospects
4.	Domestication, Acclimatization, introduction, Centre of origin/diversity
5.	Modes of reproduction and pollination, apomixes
6.	Self – incompatibility
7.	Male sterility- genetic consequences
8.	Component of Genetic variation; Heritability and genetic advance

9.	Genetic basis of self- pollinated crops and Cross Pollinated Crops
10.	Breeding methods in self- pollinated crops- mass and pure line selection
11.	Hybridization techniques
12.	Handling of segregating population (pedigree, bulk and back cross method)
13.	Multiline concept
14.	Concepts of population genetics and Hardy-Weinberg Law
15.	Population improvement and modes of selection Ear to row method, Modified Ear to Row, recurrent selection schemes
16.	Heterosis and inbreeding depression
17.	Development of inbred lines and hybrids
18.	Composite and synthetic varieties
19.	Breeding methods in asexually propagated crops
20.	Clonal selection and hybridization
21.	Wide hybridization and pre-breeding
22.	Polyploidy in relation to plant breeding
23.	Mutation breeding- methods and uses
24.	Breeding for important biotic
25.	Breeding for important abiotic stresses
26.	Biotechnological tools-DNA markers
27.	Marker assisted selection
28.	Participatory plant breeding
29.	Intellectual Property Rights and Patenting
30.	Plant Breeders and & Farmer's Rights

Topics in Practical:

S. No.	Topics
1.	Plant Breeder's kit
2.	Study of germplasm of various crops
3.	Study of floral structure of self-pollinated crops
4.	Study of floral structure of cross pollinated crops
5.	Emasculation and hybridization techniques in self-pollinated crops
6.	Emasculation and hybridization techniques in cross pollinated crops
7.	Consequences of inbreeding on genetic structure of resulting populations
8.	Study of male sterility system
9.	Handling of segregating populations
10.	Methods of calculating mean, range, variance, standard deviation, heritability
11.	Designs used in plant breeding experiment
12.	Analysis of Randomized Block Design and components of genetic variance

13.	To work out the mode of pollination in a given crop and extent of natural out crossing
14.	Prediction of performance of double cross hybrids

Suggested Readings:

- Allard, R.W. 2000.Principles of Plant Breeding. John Willey & Sons, New York.
- Chahel, G.S. and S.S. Ghosal.2002.Principles and Procedures of Plant Breeding, Biotechnological and Conventional Approaches. Narosa Publishing House, New Delhi.
- Singh, B.D. 2005. Plant Breeding. Kalyani Publishing House, New Delhi.
- Singh, P. 2001.Essentials of Plant Breeding-Principles and Methods. Kalyani Publishing House, New Delhi.

30. GPB – 221 (Principles of Seed Technology)

Credit Hours: 3 (1+2)

Topics in Theory:

S. No.	Topics
1.	Seed and seed technology: introduction, definition and importance
2.	Deterioration causes of crop varieties and their control; Maintenance of genetic purity during seed production
3.	Seed quality; Definition, Characters of good quality seed, different classes of seed
4.	Foundation and certified seed production of important cereals & fodder crops.
5.	Foundation and certified seed production of important pulses
6.	Foundation and certified seed production of important oil seed crop
7.	Foundation and certified seed production of important vegetables
8.	Seed certification, phases of certification, procedure for seed certification, field inspection
9.	Seed Act and Seed Act enforcement. Duty and powers of seed inspector, offences and penalties. Seeds Control Order 1983
10.	Varietal Identification through Grow Out Test and Electrophoresis, Molecular and Biochemical test
11.	GM crops and Detection of genetically modified crops, Transgene contamination in non-GM crops
12.	Organic seed production techniques
13.	Seed drying, processing and their steps, seed testing for quality assessment, seed treatment, its importance, method of application and seed packing
14.	Seed storage; general principles, stages and factors affecting seed longevity during storage. Measures for pest and disease control during storage
15.	Seed marketing: structure and organization, sales generation activities, promotional media. Factors affecting seed marketing, Role of WTO and OECD in seed marketing

Topics in Practical:

S. No.	Topics
1.	Seed production in wheat including seed standards
2.	Seed production in rice including seed standards
3.	Seed production in Maize including seed standards
4.	Seed production in Sorghum & Bajra including seed standards
5.	Seed production in Urd, Mung and Cowpea including seed standards
6.	Seed production in Pigeonpea including seed standards
7.	Seed production in Lentil ,Gram & Field pea including seed standards
8.	Seed production in Soybean including seed standards
9.	Seed production in Rapeseed and Mustard including seed standards
10.	Seed production in Groundnut and Sesame including seed standards
11.	Seed production in vegetable crops (Potato, Brinjal, tomato and chilli) including seed standards
12.	Seed production in Seed spices (fenugreek, , cumin & coriander) including seed standards
13.	Seed sampling methods
14.	Physical purity test
15.	Germination test
16.	Viability test
17.	Seed and seedling vigour test
18.	Genetic purity test: Grow out test
19.	Electrophoresis
20.	Seed certification: Procedure
21.	Field inspection and Preparation of field inspection report
22.	Visit to seed production farms
23.	Visit to seed testing laboratories
24.	Visit to seed processing plant

Suggested Readings:

- Agarwal, R.L.1991.Seed Technology. Oxford & IBH Publishing Co. Delhi
- Agarwal, P.K. 1999. Seed Technology. ICAR, New Delhi.
- Subir Sen and Nabinanda Ghosh.1999. Seed Science and Technology. Kalyani Publishers. New Delhi.
- Dhirendra Khare and Mohan S. Bhale.2000. Seed Technology. Scientific Publishers (India), Jodhpur.
- Maloo, S.R., Intodia, S.K. and Pratap Singh.2008. Beej Pradyogiki. Agrotech Publishing Academy.
- A.K. Joshi and B.D. Singh.2005.Seed Technology. Kalyani Publishers, New Delhi.

➢ Arya, P.S. 2001. Vegetable Breeding and Seed Production. Kalyani Pub., Ludhiana

31.GPB – 222 (Commercial Plant Breeding)

Credit Hours: 3 (1+2)

Topics in Theory:

S. No.	Topics
1.	Types of crops and modes of plant reproduction
2.	Line development and maintenance breeding in self and cross pollinated crops (A/B/R and two line system) for development of hybrids and seed Production
3.	Genetic purity test of commercial hybrids
4.	Advances in hybrid seed production of maize, rice, sorghum, pearl
5.	Millet
6.	Advances in hybrid seed production of castor, sunflower
7.	Advances in hybrid seed production of cotton, pigeon pea, brassica
8.	Quality seed production of vegetable crops under open and protected Environment
9.	Alternative strategies for the development of the line and cultivars: haploid inducer
10.	Tissue culture techniques
11.	Biotechnological tools
12.	IPR issues in commercial plant breeding
13.	DUS testing and registration of varieties under PPV & FR Act
14.	Variety testing, release and notification systems in India
15.	Types of seeds ,Principles and techniques of seed production
16.	Quality testing in self and cross pollinated crops

Topics in Practical:

S. No.	Topics
1.	Floral biology in self-pollinated species
2.	Floral biology in cross pollinated species
3.	Selfing and crossing techniques
4.	Techniques of seed production in self and cross pollinated crops using A/B/R and two line system
5.	Learning techniques in hybrid seed production using male-sterility in field crops
6.	Understanding the difficulties in hybrid seed production
7.	Tools and techniques for optimizing hybrid seed production
8.	Concept of line its multiplication and purification in hybrid seed Production
9.	Role of pollinators in hybrid seed production
10.	Hybrid seed production techniques in sorghum & Pearl millet
11.	Hybrid seed production techniques in maize

12.	Hybrid seed production techniques in rice
13.	Hybrid seed production techniques in rapeseed-mustard
14.	Hybrid seed production techniques in sunflower
15.	Hybrid seed production techniques in pigeon pea
16.	Hybrid seed production techniques in cotton
17.	Hybrid seed production techniques in vegetable crops
18.	Sampling and analytical procedures for purity testing and detection of spurious seed
19.	Seed drying
20.	Seed storage structure in quality seed management
21.	Screening techniques during seed processing viz., grading and Packaging
22.	Visit to public private seed production units
23.	Visit to public private seed processing plants

Suggested Readings:

- Chopra, V.L. 2000. *Breeding of Field Crops* (Edt.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Mandal, AK., P.K. Ganguli and S.P. Banerjee. 1991. *Advances in Plant Breeding*. Vol. I and II. CBS Publishers and Distributors, New Delhi.
- Manjit S. Kang 2004. *Crop Improvement: Challenges in the Twenty-First Century* (Edt). International Book Distributing Co. Lucknow.
- Poehlman, J.M. 1987. *Breeding of Field Crops*. AVI Publishing Co. INC, East Port, Conneacticut, USA.

32. GPB – 311 [Crop Improvement – I (Kharif crops)]

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Centers of origin, distribution of species, wild relatives in different Kharif cereals & pulses
2.	Centers of origin, distribution of species, wild relatives in different Kharif oilseeds, fibres, fodders and cash crops, vegetable and horticultural crops
3.	Plant genetic resources, its utilization and conservation of Kharif crops
4.	Study of genetics of qualitative and quantitative characters; Important concepts of breeding Kharif self-pollinated,
5.	Study of genetics of qualitative and quantitative characters; Important concepts of breeding Kharif cross pollinated
6.	Important concepts of breeding Kharif vegetatively propagated crops
7.	Major breeding objectives and procedures including conventional and modern innovative approaches for development of Kharif hybrids and varieties for yield, adaptability & stability,

8.	Important concepts of breeding for Abiotic and biotic stress tolerance of Kharif crops
9.	Important concepts of breeding for Quality (physical, chemical, nutritional) of Kharif crops
10.	Ideotype concept of Kharif crops
11.	Climate resilient Kharif crop varieties for future.

Topics in Practical:

S. No.	Topics
1.	Floral Biology, Emasculation and hybridization techniques in rice, maize
2.	Floral Biology, Emasculation and hybridization techniques in sorghum and bajra
3.	Floral Biology, Emasculation and hybridization techniques in urd, mung, cowpea, pigeonpea
4.	Floral Biology, Emasculation and hybridization techniques in, soybean, sesame
5.	Floral Biology, Emasculation and hybridization techniques in and groundnut and cotton
6.	Maintenance breeding of different kharif crops
7.	Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods
8.	Study of field techniques for seed production and hybrid seeds production in *Kharif* crops
9.	Estimation of heterosis, inbreeding depression and heritability of Kharif crops
10.	Layout of field experiments of Kharif crops
11.	Study of quality characters of Kharif crops
12.	Donor parents for different characters of Kharif crops
13.	Visit to seed production plots of Kharif crops
14.	Visit to AICRP plots of different field of Kharif crops

Suggested Readings:

- Chopra, V.L. 2000. *Breeding of Field Crops* (Edt.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chaddha. K.L. and Rajendra Gupta. 1995. Vol. II Medicinal and Aromatic Plant. Malhotra Publishing House, New Delhi.
- Mandal, A. K., P.K. Ganguli and S.P. Banerjee. 1991. *Advances in Plant Breeding.* Vol. I and II. CBS Publishers and Distributors, New Delhi.
- Manjit S. Kang 2004. *Crop Improvement: Challenges in the Twenty-First Century* (Edt). International Book Distributing Co. Lucknow.
- Poehlman, J.M. 1987. *Breeding of Field Crops.* AVI Publishing Co. INC, East Port, Conneacticut, USA.

33. GPB – 312 (Intellectual Property Rights)

Credit Hours: 1 (1+0)

Topics in Theory:

S. No.	Topics
1.	Introduction and meaning of intellectual property, brief introduction to GATT, WTO, TRIPs and WIPO
2.	Treaties for IPR protection: Madrid protocol, Berne Convention, Budapest treaty, etc
3.	Types of Intellectual Property and legislations covering IPR in India:- Patents, Copyrights, Trademark, Industrial design, Geographical indications, Integrated circuits, Trade secrets
4.	Patents Act 1970 and Patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation, infringement
5.	Compulsory licensing, Patent Cooperation Treaty, Patent search and patent database
6.	Origin and history including a brief introduction to UPOV for protection of plant varieties
7.	Protection of plant varieties under UPOV and PPV & FR Act of India, Plant breeders' rights, Registration of plant varieties under PPV&FR Act 2001
8.	Breeders, researcher and farmers rights. Traditional knowledge-meaning and rights of TK holders
9.	Convention on Biological Diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA)
10.	Indian Biological Diversity Act, 2002 and its salient features, access and benefit sharing

Suggested Readings:

- B D Singh: Principles of plant breeding, Kalyani publication, New Delhi
- Phundan Singh: IPR and plant breeders right , Kalyani publication, New Delhi
- Phundan Singh and Rajeev Singh : IPR and plant breeders right at a glance , Kalyani publication, New Delhi

34. GPB – 321 [Crop Improvement – II (Rabi Crops)]

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Centers of origin, distribution of species, wild relatives in different Rabi cereals & pulses;
2.	Centers of origin, distribution of species, wild relatives in different Rabi oilseeds, fibres, fodders and cash crops, vegetable and horticultural crops
3.	Plant genetic resources, its utilization and conservation, Rabi crops
4.	Study of genetics of qualitative and quantitative characters; Important concepts of breeding Rabi self-pollinated crops

5.	Study of genetics of qualitative and quantitative characters; Important concepts of breeding Rabi cross pollinated crops
6.	Important concepts of breeding Rabi vegetatively propagated crops
7.	Major breeding objectives and procedures including conventional and modern innovative approaches for development of Rabi hybrids and varieties for yield, adaptability stability
8.	Important concepts of breeding for Abiotic and biotic stress tolerance Rabi crops
9.	Important concepts of breeding for Quality (physical, chemical, nutritional) of Rabi crops
10.	Ideotype concept of Rabi crops
11.	Climate resilient of Rabi crop varieties for future

Topics in Practical:

S. No.	Topics
1.	Floral Biology, Emasculation and hybridization techniques in wheat, & barley
2.	Floral Biology, Emasculation and hybridization techniques in chickpea, lentil, field pea
3.	Floral Biology, Emasculation and hybridization techniques in rapeseed mustard
4.	Floral Biology, Emasculation and hybridization techniques in sunflower, potato
5.	Floral Biology, Emasculation and hybridization techniques in berseem, sugarcane
6.	Maintenance breeding of different rabi crops
7.	Handling of germplasm and segregating populations of Rabi crops by different methods like pedigree, bulk and single seed decent methods
8.	Study of field techniques for seed production and hybrid seeds production in *rabi* crops
9.	Estimation of heterosis, inbreeding depression and heritability of Rabi crops
10.	Layout of field experiments of Rabi crops
11.	Study of quality characters of Rabi crops
12.	Donor parents for different characters of Rabi crops
13.	Visit to seed production plots of Rabi crops
14.	Visit to AICRP plots of different field of Rabi crops

Suggested Readings:

- Chopra, V.L. 2000. *Breeding of Field Crops* (Edt.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Chaddha. K.L. and Rajendra Gupta. 1995. *Advances in Horticulture* Vol. II *Medicinal and Aromatic Plants*. Malhotra Publishing House, New Delhi.
- Mandal, AK., P.K. Ganguli and S.P. Banerjee. 1991. *Advances in Plant Breeding* Vol. I and II. CBS Publishers and Distributors, New Delhi.

Department – Horticulture

35. HORT – 111 (Fundamentals of Horticulture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Horticulture - Its definition and branches, importance and scope
2.	Horticultural and botanical classification
3.	Climate and soil for horticultural crops;
4.	Plant propagation-methods; Propagating structures
5.	Seed dormancy and Seed germination
6.	Principles of orchard establishment
7.	Principles and Methods of training and pruning
8.	Juvenility and flower bud differentiation;
9.	Unfruitfulness; pollination, pollinizers and pollinators
10.	Fertilization and parthenocarpy
11.	Importance and scope of medicinal and aromatic plants; Importance of plant bio-regulators in horticulture
12.	Irrigation – methods, Fertilizer application in horticultural crops

Topics in Practical:

S. No.	Topics
1.	Identification of garden tools.
2.	Identification of horticultural crops.
3.	Preparation of seed bed/nursery bed.
4.	Practice of sexual and asexual methods of propagation.
5.	Layout and planting of orchard.
6.	Training and pruning of fruit trees.
7.	Preparation of potting mixture, Fertilizer application in different crops.
8.	Visits to commercial nurseries/orchard.

Suggested Readings:

- Prasad and Kumar, Principles of Horticulture, 2nd Edn, 2014, Agrobios (India)
- Neeraj Pratap Singh, Basic concepts of Fruit Science 1st Edn, 2005, IBDC Publishers
- Edmond, J.B, Sen, T.L, Andrews, F.S and Halfacre R.G, Fundamentals of Horticulture, 1963
- Tata Mc Graw Hill Publishing Co., New Delhi
- Kumar, N, Introduction to Horticulture, 1990, Rajyalakshmi publications, Nagarcoil, Tamilnadu
- Jitendra Singh, Basic Horticulture, 2002, Kalyani Publishers, Hyderabad
- Denisen E.L., Principles of Horticulture, 1957, MacMillan Publishing Co., New York

- Chadha, K.L., Handbook of Horticulture, (ICAR),2002, ICAR, New Delhi
- K.V. Peter, Basics Horticulture, 2009, New India Publishing Agency
- Kausal Kumar Misra and Rajesh Kumar, Fundamentals of Horticulture, 2014.Biotech Books
- D.K. Salunkhe and S.S. Kadam, A handbook of Fruit Science and Technology, 2013. CRC Press
- S. Prasad and U. Kumar, A handbook of Fruit Production, 2010. Agrobios (India).
- Jitendra Singh. Basic Horticulture, 2011. Kalyani Publications, New Delhi

36. HORT – 211 (Production Technology for Vegetables & Spices)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance of vegetables & spices in human nutrition and national economy
2.	Classification of Vegetables
3.	Types of vegetable gardening with special reference to kitchen gardening
4.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders, Tomato, Brinjal, Chilli, Capsicum
5.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Cucumber, Melons, Gourds, Pumpkin
6.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of French bean, Peas
7.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Cabbage, Cauliflower, Knol-khol;
8.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Bulb crops such as Onion, Garlic
9.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Root crops such as Carrot, Radish, Beetroot
10.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Potato and Sweet potato
11.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and

	methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Leafy vegetables such as Amaranth and Palak;
12.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Perennial vegetables such as drumstick and pointed gourd
13.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of Coriander, cumin, fenugreek
14.	Origin, area, climate, soil, improved varieties and cultivation practices such as time and methods of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting and yield, physiological disorders of & fennel; Turmeric & Ginger.

Topics in Practical:

S. No.	Topics
1.	Identification of vegetables & spice crops and their seeds
2.	Nursery raising. Direct seed sowing and transplanting
3.	Study of morphological characters of different vegetables & spices
4.	Fertilizer application, Harvesting & preparation for market of Tomato, Brinjal, Chilli, Capsicum,
5.	Fertilizer application, Harvesting & preparation for market of Cucumber, Melons, Gourds, Pumpkin, French bean, Peas and Okra;
6.	Fertilizer application, Harvesting & preparation for market of Cole crops such as Cabbage, Cauliflower, Knol-khol; Bulb crops such as Onion, Garlic
7.	Fertilizer application, Harvesting & preparation for market of ; Root crops such as Carrot, Radish, Beetroot; Tuber crops such as Potato and Sweet potato; Leafy vegetables such as Amaranth and Palak
8.	Fertilizer application, Harvesting & preparation for market of Coriander, cumin, fenugreek
9.	Fertilizer application, Harvesting & preparation for market of fennel; Turmeric & Ginger
10.	Economics of vegetables and spices cultivation.

Suggested Readings:

- S. Thamburaj, 2014. Text Book of Vegetable, Tuber crops and Spices. ICAR, New Delhi
- B.R. Choudhary, 2009. A text Book on Production Technology of Vegetables. Kalyani Publishers. Ludhiana.
- T.K. Bose, 2002.Vegetable Crops. Nayaprakash. Kolkata
- T. R. Gopal Krishnan, 2007. Vegetable Crops. New India Publishing Agency. New Delhi.

- K.V. Kamath, 2007.Vegetable Crop Production. Oxford Book Company. Jaipur
- M.S. Dhaliwal, 2008. Handbook of Vegetable Crops. Kalyani Publishers. Ludhiana
- Singh, Umashankar, 2008. Indian Vegetables. Anmol Publications. Pvt. Ltd .New Delhi.
- K S Yawalkar, 2008. Vegetable crops in India. Agri-Horticultural Pub. House. Nagpur. 2004
- M.K. Rana, 2008.Olericulture in India. Kalyani Publishers. Ludhiana
- P. Hazra, 2006.Vegetable Science. Kalyani Publishers. Ludhiana
- Pratibha Sharma, 2007.Vegetables: Disease Diagnosis and Biomanagement. Avishkar Publishers. Jaipur
- Nath Prem, 1994.Vegetables for the Tropical Regions. ICAR New Delhi
- K.L. Chadha, 1993. Advances in Horticulture. Malhotra publishing house. New Delhi
- Shanmugavelu, K.G., 1989. Production Technology of Vegetable Crops. Oxford &IBH Publishing Co. Pvt. Ltd, New Delhi.
- Choudhury, B. (ICAR). 1990. Vegetables. 8th edition, National Book Trust, New Delhi.
- Singh, D.K., 2007. Modern Vegetable varieties and production. IBN publishers, Technology International Book Distributing Co, Lucknow.
- Singh, S.P. 1989. Production Technology of Vegetable Crops. ARCC, Sadar Karnal
- Chadha, K.L. 2001. Hand Book of Horticulture. ICAR, New Delhi
- Hazra, P.; Chattopadhyay, A.; Karmakar, K. and Dutta S. 2011. Modern Technology in Vegetable Production. NIPA, New Delhi
- Mourya, K.R. 2012. “Bharat Ki Salad Phasalen” Satish Serial Publishing House, Azadpur, Delhi.
- Nath, Prem and Swamy, KRM. 2016. Text Book of Vegetable Crops. ICAR, New Delhi

37. HORT – 221 [Production Technology for Ornamental Crops, MAP (Medicinal and Aromatic Plants) and Landscaping]

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance and scope of ornamental crops, medicinal and aromatic plants and landscaping
2.	Principles of landscaping. Landscape uses of trees, shrubs and climbers
3.	Production technology of important cut flowers like rose, gerbera, and carnation, under protected conditions
4.	Production technology of important cut flowers like gladiolus, tuberose, chrysanthemum under open conditions
5.	Package of practices for loose flowers like marigold and jasmine under open conditions.
6.	Production technology of important medicinal plants like ashwagandha, asparagus
7.	Production technology of important medicinal plants safed musli, aloe
8.	Production technology of important medicinal plants Cinnamon, periwinkle
9.	Production technology of important medicinal plants, isabgol and aromatic plants like

	mint
10.	Production technology of important aromatic plants, lemongrass, citronella
11.	Production technology of important aromatic plants palmarosa, ocimum,
12.	Production technology of important aromatic plants, rose, geranium, vetiver
13.	Processing and value addition in ornamental crops and MAPs produce.

Topics in Practical:

S. No.	Topics
1.	Identification of Ornamental plants. Identification of Medicinal and Aromatic Plants
2.	Nursery bed preparation and seed sowing
3.	Training and pruning of Ornamental plants. Planning and layout of garden
4.	Bed preparation and planting of MAP
5.	Protected structures – care and maintenance.
6.	Intercultural operations in flowers and MAP.
7.	Harvesting and post-harvest handling of cut and loose flowers
8.	Processing of MAP
9.	Visit to commercial flower/MAP unit

Suggested Readings:

- A.K.Singh.2006.Flower crops, cultivation and management. New India publishing agency, Pitampura, New Delhi.
- T.K. Bose, L.P. Yadav, P. Patil, P. Das and V.A. Partha Sarthy.2003.Commercial flowers. Partha Sankar Basu, Nayaudyog,206, Bidhan Sarani, Kolkata-700006
- S.K. Bhattacharjee and L.C. De. 2003. Advanced Commercial Floriculture. Aavishkar Publishers, Distributors, Jaipur (Rajasthan) India.
- Dewasish Choudhary and Amal Mehta. 2010. Flower crops cultivation and management. Oxford book company Jaipur, India.
- Randhawa, G.S. Amitabha Mukhopadhyay, 2004. Floriculture in India. Allied Publishers Pvt. Ltd:
- Arora, J.S. 2006. Introductory Ornamental Horticulture. Kalyani Publishers, Ludhiana - 141 008.
- Prof. Bhattacharjee, S.K. Advanced Commercial Floriculture. Aavishkar Publishers Distributors, Jaipur - 320 003
- Prof. V.L. Sheela, 2008. Flowers for trade. New India Publishing Agency, Pitampura, New Delhi-110088
- Chadha, K.L. ICAR, 2001. Hand Book of Horticulture. Directorate of Information and Publications of Agriculture, Pusa, New Delhi.
- Azhar Ali Farooqui and Sreeramu, B.S. 2001.Cultivationofmedicinalandaromaticplants.United Press Limited.
- Atal,E.K. and Kapur,B.1982.Cultivation and Utilization of Medicinal and Aromatic plants.CSIR, New Delhi.

- Kumar,N.J.B.M.Md.AbdulKhaddar,RangaSwamy,P.andIrulappan,I.1997.Introduction toSpices,PlantationCropsMedicinalandAromaticPlants.Oxford&IBH,NewDelhi.
- Jain,S.K.1968.MedicinalPlants.NationalBookTrustNewDelhi.Oxford&IBH,NewDelhi.

38. HORT – 222 (Production Technology for Fruit and Plantation Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance and scope of fruit and plantation crop industry in India, Importance of rootstocks
2.	Production technologies for the cultivation of major fruits-Mango, Banana.
3.	Production technologies for the cultivation of major fruits-Citrus,
4.	Production technologies for the cultivation of major fruits-Grape
5.	Production technologies for the cultivation of major fruit guava, papaya,
6.	Production technologies for the cultivation of major fruit litchi, sapota,
7.	Production technologies for the cultivation of apple, pear, peach,
8.	Production technologies for the cultivation of walnut, almond
9.	Production technologies for the cultivation of minor fruits- Date palm, Ber,
10.	Production technologies for the cultivation of Pineapple, Aonla,
11.	Production technologies for the cultivation of Pomegranate, jackfruit,
12.	Production technologies for the cultivation of Strawberry, Custard apple
13.	Production technologies for the cultivation of, Bael and Coconut
14.	Production technologies for the cultivation of, arecanut, cashew,
15.	Production technologies for the cultivation of, tea, coffee & rubber.

Topics in Practical:

S. No.	Topics
1.	Description and identification of fruit and plantation crops
2.	Seed propagation, Scarification and stratification of seeds
3.	Propagation methods for fruit and plantation crops including micro propagation
4.	Preparation of plant bio regulators and their uses,
5.	Important pests, diseases and physiological disorders of major fruits
6.	Important pests, diseases and physiological disorders of minor fruits
7.	Important pests, diseases and physiological disorders of plantation crops
8.	Visit to commercial orchards

Suggested Readings:

- H. P. Singh and M. M. Mustafa, 2009. Banana-new innovations. Westville Publishing House,
- New Delhi.
- M. S. Ladaniya, 2013. Citrus Fruits. Elsevier, India post ltd.
- Bose, T.K., Mitra, S.K. and Sanyal, D., 2002. Tropical and Sub-Tropical-Vol-I. Nayaudyog-Kolkata
- Rajput, CBS and Sriharibabu, R., 1985. Citriculture. Kalyani Publishers, New Delhi.
- Chundawat, B.S., 1990. Arid fruit culture. Oxford and IBH, New Delhi.
- Chadha, K. L. (ICAR) 2002, 2001. Hand book of Horticulture. ICAR, New Delhi.
- Symmonds, 1996. Banana. II Edn. Longman, London.
- Radha, T. and Mathew, L., 2007. Fruit crops. New India Publishing Agency.
- W. S. Dhillon, 2013. Fruit Production in India. Narendra Publishing House, New Delhi
- T. K. Chattopadhyay, 1997. Text book on pomology. Kalyani Publishers, New Delhi.
- R.E. Litz, 2009. The Mango 2nd Edn. Cabi Publishing, Willingford, U.K.
- K. L. Chadda, 2009. Advanced in Horticulture. Malhotra Publishing House, New Delhi.
- S.P. Singh, 2004. Commercial fruits. Kalyani Publishers, New Delhi.
- F.S. Davies and L.G. Albrigo, 2001. Citrus, Cab International.
- Kumar, N.J.B. M. Md. Abdul Khaddar, Ranga Swamy, P. and Irrulappan, I. 1997. Introduction to spices, Plantation crops and Aromatic plants. Oxford & IBH, New Delhi.
- Thampan, P.K. 1981.Hand Book of Coconut Palm. Oxford IBH, New Delhi.
- Nair, M.K., Bhaskar Rao, E.V.V., Nambiar, K.K.N. and Nambiar, M.C. 1979. Cashew, CPCRI, Kerala.
- Ranganadhan, V. 1979. Hand Book of Tea Cultivation. UPASI Tea Research Station, Cinchona.
- Thompson, P.K. 1980. Coconut. Oxford & IBH Publishing Co. Ltd., New Delhi

39. HORT – 321 (Post-harvest Management and Value Addition of Fruits and Vegetables)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance of post-harvest processing of fruits and vegetables, extent and possible causes of post-harvest losses
2.	Pre-harvest factors affecting postharvest quality
3.	Maturity, ripening and changes occurring during ripening;
4.	Respiration and factors affecting respiration rate; Role of ethylene
5.	Post-harvest disease and disorders
6.	Harvesting and field handling; Storage (ZECC, cold storage, CA, MA, and hypobaric)
7.	Value addition concept; Principles and methods of preservation
8.	Intermediate moisture food- Jam, jelly, marmalade, preserve, candy – Concepts and

	Standards
9.	Fermented and non-fermented beverages
10.	Tomato products- Concepts and Standards
11.	Drying/ Dehydration of fruits and vegetables – Concept and methods, osmotic drying
12.	Canning - Concepts and Standards.
13.	Packaging of products

Topics in Practical:

S. No.	Topics
1.	Identification and applications of different types of packaging, containers for shelf life extension.
2.	Identification of important tools/equipments/ machines and chemicals required for PHT laboratory
3.	Demonstration of Zero energy cool chamber
4.	Effect of temperature on shelf life and quality of produce
5.	Extraction and preservation of pulps and juices
6.	Preparation of Jam, Jelly, Pickles
7.	Preparation of RTS, nectar, squash, osmotically dried products,
8.	Preparation of fruit bar and candy and tomato products (sauce and ketchup
9.	Preparation of canned products.
10.	Quality evaluation of products physicochemical (Moisture, TSS, acidity and ascorbic acid) and sensory
11.	Visit to processing unit/ industry

Suggested Readings:

- Verma, L. R. and Joshi, V. K. 2000. Post-Harvest Technology of Fruits and Vegetables. Vol. I & II. Indus Publishing Co., New Delhi
- Wills, McGlasson and Graham, J. 2007. Post-Harvest- An Introduction to the Physiology and Handling of Fruits, Vegetables and ornamentals. Cab International
- Stanley, J. K. 1998. Post-Harvest Physiology of Perishable Plant Products. CBS, New Delhi.
- Neetu Sharma and Mashkoor Alam, M. 1998. Post-Harvest Diseases of Horticultural Perishables. International Book Distributing Co., Lucknow.
- Chadha, K. L. and Kalloo, G.1993. Advances in Horticulture. Vol. 4 to 10. MPH, New Delhi.
- Shanmugavelu, K. G., Kumar, N. and Peter K.V. 2002. Production Technology of Spices and Plantation Crops. Agrobios (India).
- Saraswathy, S. et. al. 2008. Post-harvest Management of Horticultural Crops. Agribios (India).81-7754-322-9.
- Kitinoja, L. and Kader, A. A. 2003. Small-Scale Postharvest Handling practice: A Manual for Horticulture crops (4th Edn.). US Davis, PHT Research and information Center.

Department – Mathematics and Statistics
40. AST – 111 (Elementary Mathematics)

Credit Hours: 1 (1+0)

Topics in Theory:

S. No.	Topics
	STRAIGHT LINES
1.	Distance formula, section formula (internal and external division), Change of axes (only origin changed), Equation of co-ordinate axes, Equation lines parallel to axes
2.	Slope–intercept form of equation of line, Slope-point form of equation of line, Two point form of equation of line, Intercept form of equation of line
3.	Normal form of equation of line, General form of equation of line
4.	point of intersection of two straight lines, angle between two straight lines, parallel lines, Perpendicular lines
5.	Angle of bisectors between two lines, Area of triangle and quadrilateral
	CIRCLE
6.	Equation of circle whose centre and radius is known and its particulars cases, general equation of a circle
7.	Equation of circle passing through three given points, Equation of circle whose diameters is line joining two points (x_1, x_2) & (y_1, y_2)
8.	Tangent and normal to a given circle at given point (Simple problems), condition of tangency of a line $y= mx + c$ to the given circle $x^2 + y^2 = a^2$
	DIFFERENTIAL CALCULUS
9.	Definition of Function, Limit and Continuity, Fundamental theorem on Limits
10.	Evaluation of Algebraic limits by direct substitution method, factorization method, Rationalization method and by using some standard limits.
11.	Simple problem based on Continuity at a point
12.	Differentiation of x^n, e^x, sinx & cos x from I principles
13.	Derivatives of some difference, product & quotient of two functions
14.	Differentiation of functions of functions
15.	Differentiation of logarithmic functions and Inverse trigonometric functions
16.	Maxima and minima of the functions of the form y=f(x)
	INTEGRAL CALCULUS
17.	Integration formulae
18.	Integration of simple functions
19.	Methods of integration - Integration by Substitution, Integration by parts
20.	Definite integral and Area under Curves
	MATRICES AND DETERMINANT
21.	Definition of Matrices- Row matrix, Column matrix, Null matrix, Square matrix, Diagonal matrix, Scalar matrix, Unit matrix, Equal matrices, Symmetric matrix, Skew symmetric matrix, Singular and Non- Singular matrices

22.	Addition and Subtraction of matrices,
23.	Scalar multiplication, Multiplication of matrices,
24.	Transpose of matrices, Inverse of a matrix upto 3rd order
25.	Determinants- definition, Minor and Co-factor of an element of determinant upto 3rd order

Suggested Readings:

- Krishi Ganita by Gokhroo and Jain
- Differential Calculus by Gokhroo.
- Integral Calculus by Gokhroo.
- Narayan Shanti & Mittal PK.2006, Differential Calculus.
- S. Chand & company Ltd. Ram Nagar, New Delhi 2006, Integral Calculus.
- Sharma R.D. 2012. Mathematics, Dhanpat Rai Publications Dariyaganj, New Delhi

41. AST – 211 (Agri-Informatics)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to Computers: Anatomy of Computers, Memory concepts, Units of memory
2.	Operating System: DOS and Windows- definition and types
3.	Applications of MS-Office: Document creation and Editing in MS-Word Data handling in MS-Excel, data presentation, interpretation and graph creation (Bar, Line, Pie, Diagram and Histogram) MS-PowerPoint presentation
4.	Statistical analysis: Mean, Standard Deviation, Correlation, regression using mathematical expressions and analysis tools in Excel
5.	Database: concepts and types and uses of database in Agriculture- use of DBMS (MS-Access)
6.	World Wide Web (WWW): Elementary Concepts, Internet Explorer (IE), Search Engine (Google), Email
7.	Introduction to Computer Programming Languages: Standard input/output operations in BASIC, Basic language- (programming codes for only calculating mean standard deviation)
8.	e-Agriculture and ICT: Concepts and Applications, use of ICT in Agriculture. Computer Models for understanding plant processes. IT application for computation of water and nutrient requirement of crops.
9.	Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in Agriculture for farm advises, market price, postharvest

	management etc; Geospatial technology for generating valuable agricultural information. Decision support systems, concepts, components and applications in Agriculture Agriculture Expert System, Soil Information Systems etc for supporting Farm decisions, Preparation of contingent crop-planning using IT tools

Topics in Practical:

S. No.	Topics
1.	Introduction to Computers and Operating System: Display of Computer Components, accessories, Creating Files & Folders, File Management using DOS and Windows OS
2.	Application of MS-Office: Use of MS-Word and MS Power-point for creating, editing and presenting a scientific Document. MS-Excel: Creating a spread sheet, creating graph (Bar, line ,Pie diagrams and histogram), analysis of scientific data.
3.	Statistical Analysis: Use of Statistical tools and writing mathematical expressions using MS- Excel, Calculation of Mean, Standard Deviation , Correlation and Regression using Mathematical Expression in Excel.
4.	Database in Agriculture: MS-Access: Creating database, preparing queries and reports, demonstration of Agri-information system.
5.	World Wide Web(WWW): Display of Introductory Concepts in Internet Explorer (IE), Search Engine (Google), Creation of Email.
6.	Introduction to computer programming languages: Practical on standard Input / Output Operation in BASIC, BASIC language (Programming codes for only calculating Mean and Standard Deviation).
7.	Preparation of contingent crop planning using ICT
8.	e-Agriculture : Practical Hands on Crop Simulation Models (CSM) such as DSSAT/ Crop-Info/ Crop Syst/ Wofost: Computation of water and nutrient requirements of crop using CSM and IT tools. Display if Introductory Geospatial Technology using a GIS software system for generating valuable information for agriculture. Practical Hands on Decision Support system in Agriculture.
9.	Introduction of Geospatial Technology, for generating information important for Agriculture. Introduction of Geospatial Technology for generating valuable information for Agriculture
10.	Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, Hands on Decision Support System, Preparation of Contingent Crop Planning

Suggested Readings:

- Gurvinder Singh, Rachhpal Singh & Sluja KK. 2003 Fundamentals of Computer Programming and Information Technology. Kalyani Publishers.
- Harshwardhan P. Bal. 2003. Perl Programming for Bioinformatics. Tata Mc Graw-Hill Education.

- Kumar A 2015. Computer Basics with Office Automation. IK International Publishing House Pvt Ltd.
- Rajaraman V & Adabala N. 2015. Fundamentals of Computers. PHI.

42. AST – 212 (Statistical Methods)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to statistics and its applications in Agriculture
2.	Graphical representation of data: Histogram, Frequency Polygon, Frequency Curve
3.	Meaning of Central tendency, Requisites for an Ideal measure of Central Tendency
4.	Different measures of Central Tendency (for both ungrouped and grouped data) Arithmetic mean, Median and Mode along with their merits and demerits
5.	Partition values (for both ungrouped and grouped data): Quartiles, Deciles and Percentiles
6.	Meaning of Dispersion, Range, Quartile Deviation, Mean Deviation, and Standard Deviation (for both ungrouped and grouped data) along with their merits and demerits, Coefficient of variation and its uses
7.	Moments (Central), Measures of skewness and kurtosis for both ungrouped and grouped data
8.	Probability: Basic terminology, Classical definition of probability and its limitations, Addition and Multiplication Theorem (without proof).
9.	Discrete Probability distributions: Binomial and Poisson distribution-Definition, Conditions for the application, properties
10.	Correlation and regression: Scatter diagram, types of correlation, Karl Pearson's coefficient of correlation, properties of correlation coefficient, linear regression-regression coefficient, Properties of regression coefficients, and two lines of regression
11.	Introduction to test of significance: Types of hypothesis, two types of errors, critical region, level of significance, degrees of freedom, Student's t-test, Fisher's t-test, Chi-square test of goodness of fit, Chi-square test of independence of attributes for 2x2 contingency table
12.	Introduction to analysis of variance: Definition, assumptions, analysis of variance - one way classification and two-way classification
13.	Introduction to Sampling methods: Sampling versus Complete enumeration, Simple Random Sampling with and without replacement, use of random number tables for selection of simple random sample

Topics in Practical:

S. No.	Topics
1.	Construction of Histogram, Frequency Polygon, Frequency Curve
2.	Computation of Mean, Median and Mode for both Grouped and Ungrouped data
3.	Computation of Quartiles, Deciles and Percentiles for both Grouped and Ungrouped data

4.	Computation of Range, Quartile Deviation, Mean Deviation, Standard Deviation and CV for both Grouped and Ungrouped data
5.	Computation of Central Moments, coefficient of Skewness and Kurtosis for both ungrouped and grouped data
6.	Calculation of Simple correlation and Regression coefficient along with fitting of two regression lines
7.	Problems based on one sample t-test, two sample Fisher's t-test, Chi-Square test of goodness of fit, Chi-Square test of independence of attributes for 2×2 contingency table
8.	Problem based on analysis of variance for one way and two-way classification
9.	Selection of random sample using Simple Random Sampling

Suggested Readings:

- Chandel, S.R.S. 1998. Handbook of Agril. Statistics. Achal Prakashan Mandir, Kanpur.
- Gupta S.C. and V.K. Kapoor. 2007. Fundamentals of Mathematical Statistics. Sultan Chand & Sons, New Delhi.
- Agarwal, B.L. 2001. Basic Statistics, New Age International (P) Limited, Publishers, New Delhi.
- Rangaswamy, R. 2000. A Text Book of Agricultural Statistics. New Age International (P) Limited, Publishers, Daryaganj, New Delhi

Department – Plant Pathology

43. PPT – 121 (Fundamentals of Plant Pathology)

Credit Hours: 4 (3+1)

Topics in Theory:

S. No.	Topics
1.	Introduction: Importance of plant diseases, scope and objectives of Plant Pathology
2.	History of Plant Pathology with special reference to Indian work
3.	Terms and concepts in Plant Pathology
4.	Pathogenesis: causes / factors affecting disease development: disease triangle and tetrahedron
5.	Classification of plant diseases
6.	Important plant pathogenic organisms
7.	Different groups of fungi, bacteria, fastidious vesicular bacteria, phytoplasmas, spiroplasmas
8.	Different groups of viruses, viroids, algae and protozoa
9.	Phanerogamic parasites and nematodes with examples of diseases caused by them
10.	Diseases and symptoms due to abiotic causes
11.	Fungi :general characters, definition, somatic structures types of fungal thalli, fungal tissues, modifications of thallus
12.	Reproduction in fungi (asexual and sexual).
13.	Nomenclature, binomial system of nomenclature, rules of nomenclature, classification of fungi
14.	Key to divisions , sub-divisions, orders and classes of fungi
15.	Bacteria and mollicutes: general morphological characters, basic methods of classification and reproduction
16.	Viruses: nature, structure, replication and transmission
17.	Study of phanerogamic plant parasites
18.	Nematodes: general morphology and reproduction, Nematode classification
19.	Symptoms and nature of damage caused by plant parasitic nematodes (Heterodera, Meloidogyne, Anguina, Radopholus etc.)
20.	Growth and reproduction of plant pathogens
21.	Liberation / dispersal and survival of plant pathogens
22.	Types of parasitism and variability in plant pathogens, Pathogenesis
23.	Role of enzymes, toxins and growth regulators in disease development
24.	Defense mechanism in plants
25.	Epidemiology: Factors affecting disease development.
26.	Principles and methods of plant disease management
27.	Nature, chemical combination, classification, mode of action and formulations of fungicides and antibiotics.

Topics in Practical:

S. No.	Topics
1.	Acquaintance with various laboratory equipments and microscopy
2.	Collection and preservation of disease preparation
3.	Preparation of media, isolation and Koch's postulates
4.	General study of different structures of fungi
5.	Study of symptoms of various plant diseases
6.	Study of representative fungal genera.
7.	Transmission of plant viruses.
8.	Study of morphological features and identification of plant parasitic nematodes.
9.	Sampling and extraction of nematodes from soil and plant material, preparation of nematode mounting.
10.	Staining and identification of plant pathogenic bacteria.
11.	Study of phanerogamic plant parasites.

Suggested Readings:

- Agrios, G.N. (2005). Plant Pathology. 5th Edn. Academic Press, New York, USA.
- Bhale, U, Mishra M. ,Kumar, S. and Gupta, OM (2015). Laboratory Manual on Plant
- Pathology, A S AP Publisher.
- Bilgrami, K.S. and Dube, H.C. (1990). A Text book of Modern Plant Pathology, Vikas Publishing House Pvt. Ltd, India; New Ed edition.
- Kamat, M.N. (1967). Introductory Plant Pathology, 3rdEds revised, Prakash Publisher,
- Jaipur.
- Malhrotra, R.S. (2003). Plant Pathology, Tata McGraw-Hill Education,
- Nene, Y.L. and Thapliyal, P. L. (1987). Fungicides in Plant Disease Control, 2ndeds.
- Oxford & IBH Publishing, New Delhi.
- Pathak, V.N. (1972). Essentials of Plant Pathology, Prakash publisher, Jaipur.
- Sathe, T.V. (2011). Agrochemicals and Pest Management, Daya Publishing House.
- Sharma, C.S. (2013). Plant Pathology, Published by Agrotech Press.
- Sharma, P.D. (2013). Plant Pathology, Rastogi Publications, Meerut.
- Sharma, R. (2012). PlantVirus, ABD publisher.
- Singh, R.S. (1990). Plant Diseases. 9th Eds. Oxford & IBH Publishing Company.

46. PPT – 312 (Principles of Integrated Pest and Diseases Management)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Categories of insect pests and diseases,
2.	IPM: Introduction, history, importance, concepts, principles and tools of IPM.
3.	Economic importance of insect pests, diseases and pest risk analysis.
4.	Methods of detection and diagnosis of insect pest. Calculation and dynamics of economic injury level and importance of Economic threshold level.
5.	Methods of detection and diagnosis of diseases.
6.	Methods of control: Host plant resistance, cultural, mechanical, physical, legislative, biological and chemical control. Ecological management of crop environment.
7.	Introduction to conventional pesticides for the insect pests and disease management.
8.	Survey surveillance and forecasting of Insect pest and diseases.
9.	Development and validation of IPM module.
10.	Implementation and impact of IPM (IPM module for Insect pest and disease.
11.	Safety issues in pesticide uses.
12.	Political, social and legal implication of IPM.
13.	Case histories of important IPM programmes.

Topics in Practical:

S. No.	Topics
1.	Methods of diagnosis and detection of various plant disease and their measurement
2.	Mass multiplication of *Trichoderma and Pseudomonas*.
3.	Identification and nature of damage of important diseases and their management
4.	Crop (agro-ecosystem) dynamics of selected diseases.
5.	Crop monitoring attacked by diseases
6.	Methods of diagnosis and detection of various insect pests.
7.	Methods of insect pests' measurement,
8.	Assessment of crop yield losses, calculations based on economics of IPM,
9.	Identification of biocontrol agents, different predators and natural enemies. Mass multiplication of *Trichogramma* and NPV.
10.	Identification and nature of damage of important insect pests and their management.
11.	Plan & assess preventive strategies (IPM module) and decision making, crop monitoring attacked by insect, pest and diseases.
12.	Awareness campaign at farmers' fields

Department - Biochemistry/Physiology/Microbiology/ Environmental Science

47. EVS-111 (Fundamentals of Plant Biochemistry and Biotechnology)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Importance of Biochemistry.
2.	Properties of Water, pH and Buffer.
3.	Carbohydrate: Importance and classification. Structures of Monosaccharides, Reducing and oxidizing properties of Monosaccharides, Mutarotation; Structure of Disaccharides and Polysaccharides.
4.	Lipid: Importance and classification; Structures and properties of fatty acids; storage lipids and membrane lipids.
5.	Proteins: Importance of proteins and classification; Structures, titration and zwitterions nature of amino acids; Structural organization of proteins.
6.	Metabolism of carbohydrates and lipids
7.	Concepts and application of plant biotechnology : Scope, organ culture, embryo culture, cell suspension culture, callus culture, anther culture, pollen culture and ovule culture and their applications;
8.	Micro-propagation methods; organogenesis and embryogenesis, Synthetic seeds and their significance; Embryo rescue and its significance; somatic hybridization and cybrids;
9.	Somaclonal variation and its use in crop improvement; cryo-preservation;
10.	Introduction to recombinant DNA methods: physical (Gene gun method), chemical (PEG mediated) and Agrobacterium mediated gene transfer methods;
11.	Transgenics and its importance in crop improvement;
12.	PCR techniques and its applications;
13.	RFLP, RAPD, SSR;
14.	Marker Assisted Breeding in crop improvement;
15.	Biotechnology regulations

Topics in Practical:

S. No.	Topics
1.	Preparation of solution, pH & buffers
2.	Qualitative tests of carbohydrates and amino acids.
3.	Quantitative estimation of glucose/ proteins
4.	Titration methods for estimation of amino acids/lipids, ,
5.	Effect of pH, temperature and substrate concentration on enzyme action
6.	Paper chromatography/ TLC demonstration for separation of amino acids/ Monosaccharides.

7.	Sterilization techniques.
8.	Composition of various tissue culture media and preparation of stock solutions for MS nutrient medium
9.	Callus induction from various explants.
10.	Micro-propagation, hardening and acclimatization
11.	Demonstration on isolation of DNA.
12.	Demonstration of gel electrophoresis techniques and DNA finger printing

Suggested Readings:

- Plant Biochemistry- V. Arun Kumar, N. Senthil Kumar and K. Siva Kumar, 2010, APH Publishing Corporation, New Delhi.
- Biotechnology-Expanding Horizons, B.D. Singh, 2014, Kalyani Publishers, Ludhiana
- Principles and Techniques of Biochemistry and Molecular Biology, Eds. Keith Wilson and John Walker, 7th Edition, 2010, Cambridge University Press
- A Textbook of Biotechnology, Revised Edition, 2014, R.C. Dubey, S. Chand Publishing Company, New Delhi
- Lehninger Principles of Biochemistry by Albert Lehninger, David Nelson and Michael Cox, Seventh Edition, 2017 Macmilla.

48. EVS – 112 (Introduction to Forestry)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction – definitions of basic terms related to forestry
2.	Objectives of silviculture, forest classification, salient features of Indian Forest Policies
3.	Forest regeneration, Natural regeneration - natural regeneration from seed and vegetative parts, coppicing, pollarding, root suckers
4.	Artificial regeneration – objectives, choice between natural and artificial regeneration, essential preliminary considerations
5.	Crown classification. Tending operations – weeding, cleaning, thinning – mechanical, ordinary, crown and advance thinning
6.	Forest mensuration – objectives, diameter measurement, instruments used in diameter measurement
7.	Non instrumental methods of height measurement - shadow and single pole method
8.	Instrumental methods of height measurement - geometric and trigonometric principles, instruments used in height measurement; tree stem form, form factor, form quotient, measurement of volume of felled and standing trees, age determination of trees
9.	Agroforestry – definitions, importance, criteria of selection of trees in agroforestry, different agroforestry systems prevalent in the country, shifting cultivation, taungya, alley cropping, wind breaks and shelter belts, home gardens
10.	Cultivation practices of two important fast growing tree species of the region

Topics in Practical:

S. No.	Topics
1.	Identification of tree-species
2.	Diameter measurements using calipers and tape, diameter measurements of forked, buttressed, fluted and leaning trees
3.	Height measurement of standing trees by shadow method, single pole method and hypsometer
4.	Volume measurement of logs using various formulae
5.	Nursery lay out, seed sowing, vegetative propagation techniques
6.	Forest plantations and their management
7.	Visits of nearby forest based industries

Suggested Readings:

- Indian Forestry- by K. Manikandan and S. Prabhu.
- Principles and Practices of Silviculture- by A. P. Dwivedi.
- Silviculture- by L. S Khanna
- Forest Mensuration – by Lal

49. EVS – 113 (Introductory Biology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to the living world and diversity, difference between living and non-living, properties of living organisms,
2.	Origin of life : Fossil, history of studies into the origin of life, early condition on earth, origin of organic molecules, RNA metabolism, protein and lipid theories,
3.	Eugenics : meaning, type and development of eugenics, Evolution: heredity, variation, mechanism and outcome of evolution, difference between eugenic and evolution.
4.	Binomial nomenclature and classification: Definition, system and rules, Cell : plant and animal cell differences and their function, cell division: Mitosis and meiosis
5.	Morphology of flowering plants: types and modification of leaf, stem, root, Parts of flower and inflorescence
6.	Seed structure: Monocot and dicot seed, Seed germination, factors affecting seed germination.
7.	Plant systematic- viz; Brassicaceae, Fabaceae, Solanceae and Poaceae
8.	Role of animals in agriculture

Topics in Practical:

S. No.	Topics
1.	Morphology of flowering plants – root, stem and leaf and their modifications
2.	Inflorence, flower and fruits.
3.	Cell, tissues
4.	cell division
5.	Internal structure of root, stem and leaf.
6.	Study of specimens and slides.

Suggested Readings:

- Practical Manual on Introductory Biology by Mithlesh Kumar, Praveen Kumar and Tribhuvan Das. Kalyani Publications.

50. EVS - 121 (Fundamentals of Crop Physiology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction: Definition of crop physiology and its importance in Agriculture and Horticultural crops
2.	Plant cell: an overview discussion, structure and functions of cell organelles
3.	Diffusion and Osmosis: Definition, differences and its importance in plant physiology
4.	Plant water relationship: concept, Importance of water, water absorption mechanism
5.	Transpiration: definition and significance of transpiration in relation to crop productivity; Stomatal physiology: structure, frequency, distribution and stomatal opening and closing mechanism
6.	Mineral Nutrition: Criteria of essentiality, beneficial nutrients, Functions and deficiency symptoms of nutrients, mineral salt absorption mechanism
7.	Photosynthesis: Light and dark reaction, C3, C4 and CAM plants and photorespiration
8.	Respiration: Glycolysis, TCA cycle and ETS
9.	Fat Metabolism: fatty acid synthesis and its breakdown
10.	Plant growth regulators: Definition, classification and role of PGRs in agricultural crops
11.	Physiological aspects of growth and development of major crops
12.	Growth analysis: definitions and mathematical formulae, role of growth parameters in crop productivity

Topics in Practical:

S. No.	Topics
1.	Plant cell: An overview study, Structure and functions of major plant cell organelles
2.	Structure and distribution of stomata

3.	Demonstration of imbibition's, osmosis and plasmolysis
4.	Measurement of root pressure
5.	Measurement of transpiration by different methods
6.	Separation of photosynthetic pigments through paper chromatography
7.	Measurement of respiration by using Ganong's respirometer
8.	Tissue tests for mineral nutrients
9.	Estimation of relative water content (RWC)
10.	Measurement of photosynthetic CO_2 assimilation by Infra-Red Gas Analyser (IRGA)

Suggested Readings:

- N. K. Gupta & Sunita Gupta, (2004). Plant Physiology. Oxford and IBH publication, New Delhi.
- S. N. Pandey and B. K. Sinha (1995). Vikas Publishing House Pvt. Ltd., new Delhi
- J. B. Salisbury and C.W. Ross (1992). Plant Physiology, Wadswar Publishing Company, Belmont, California
- L. Taiz and E. Zieger (2006). Plant Physiology. 4th Ed. Sinauer Associates.
- C.P. Malik and A.K. Srivastava (2015), Text Book of Plant Physiology.
- R.K. Sinha (2015), Modern Plant Physiology.
- V.K. Jain (2015),Fundamentals of Plant Physiology
- Gontia, A. S. (2016). A Text Book of Plant Physiology(e-book) :Publisher, Satish Serial.

51. EVS - 122 (Agricultural Microbiology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction. Microbial world: Prokaryotic and eukaryotic microbes.
2.	Bacteria: Cell structure, chemoatotrophy, photoautotrophy, growth
3.	Bacterial genetics: genetics recombination- transformation, conjugation, and transduction, plasmids, transposon
4.	Soil organisms: macro and microorganisms, their beneficial and harmful effects
5.	Role of microbes in soil fertility and crop production: Carbon, Nitrogen, Phosphorus and Sulphur cycles.
6.	Biological nitrogen fixation- symbiotic, associative and asymbiotic.
7.	Azolla, blue green algae and mycorrhiza
8.	Rhizosphere and phyllosphere
9.	Microbes in human welfare: silage production, bio-fertilizers, bio-pesticides, bio-fuel production and
10.	Bio-degradation of agro-waste.

Topics in Practical:

S. No.	Topics
1.	Introduction to microbiology laboratory and its equipments;
2.	Microscope- parts, principles of microscopy, resolving power and numerical aperture
3.	Methods of sterilization.
4.	Nutritional media and their preparations
5.	Enumeration of microbial population in soil- bacteria, fungi, actinomycetes
6.	Methods of isolation and purification of microbial cultures.
7.	Isolation of Rhizobium from legume root nodule
8.	Isolation of Azotobacter from soil
9.	Isolation of Azospirillum from roots
10.	Isolation of BGA
11.	Staining and microscopic examination of microbes

Suggested Readings:

- Rangaswami and Bhagyaraj :Agricultural Microbiology
- N.S. Subbarao : Soil Microbiology
- N. Mukherjee and T. Ghosh :Agricultural Microbiology
- L.L. Somani, S.C. Bhandari S.N. Saxena : Biofertilizers
- M. Alexender : Introduction to soil Microbiology
- P. Tauro, K.K. Kapoor and K.S. Yadav :An Introduction to Microbiology

52. EVS – 211 (Environmental Studies and Disaster Management)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Multidisciplinary nature of environmental studies, Definition, scope and importance
2.	Natural Resources: Renewable and non-renewable resources, Natural resources and associated problems. Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
3.	Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
4.	Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
5.	Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources.
6.	Land resources: Land degradation; man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources, Equitable use of resources for sustainable lifestyles.

7.	Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem. Ecological succession, Food chains, food webs
8.	Ecological pyramids: Introduction, types, characteristic features, structure and function of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)
9.	Biodiversity and its conservation: - Introduction, definition, genetic, species & ecosystem diversity and biogeographical classification of India. Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.
10.	Biodiversity at global, National and local levels, India as a mega-diversity nation. Hot-sports of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.
11.	Environmental Pollution: definition, cause, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards. Solid Waste Management: causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution.
12.	Social Issues and the Environment: From Unsustainable to Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting and watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust and dies.
13.	Wasteland reclamation. Consumerism and waste products. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation. Public awareness.
14.	Human Population and the Environment: population growth, variation among nations, population explosion, Family Welfare Programme. Environment and human health: Human Rights, Value Education, HIV/AIDS. Women and Child Welfare. Role of Information Technology in Environment and human health.
15.	Disaster Management: Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: global warming, Sea level rise, ozone depletion.
16.	Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.
17.	Disaster Management- Effect to migrate natural disaster at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community – based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response; Police and other organizations.

Topics in Practical:

S. No.	Topics
1.	Study of natural ecosystem: Pond, river, and forest. and artificial ecosystem: etc.
2.	Study of artificial ecosystem: Crop land ecosystem
3.	Identification of common plants, insects and birds
4.	Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
5.	Pollution Case Studies: case study and visit to a local area to document environmental assets river/ forest/ grassland/ hill/ mountain.

Suggested Readings:

- Environmental Science - Bharucha Erach, 2017, University Grant Commission
- Environmental and Ecology - Hussain Majid,2013, Online book
- Environmental Biotechnology - Agrawal SK,2002, APH Publishing Corporation, New Delhi
- Introduction to Environment Science – Sharma JP,2003, Laxmi Publication, New Delhi
- Environment Geography – Singh Svindra,2015, Pryaga Pustak Bhawan, Allahabad
- Ecology and Environment – Ojha AK, 2017, Bodhik Publication, Allahabad

53. EVS – 321 (Principles of Food Science and Nutrition)

Credit Hours: 2 (2+0)

Topics in Theory:

S. No.	Topics
1.	Concepts of Food Science (definitions, measurements, density, phase change, pH, osmosis, surface tension, colloidal systems etc.);
2.	Food composition and chemistry (water, carbohydrates, proteins, fats, vitamins, minerals, flavours, colours, miscellaneous bioactives, important reactions)
3.	Food microbiology (bacteria, yeast, moulds, spoilage of fresh & processed foods, Production of fermented foods)
4.	Principles and methods of food processing and preservation (use of heat, low temperature, chemicals, radiation, drying etc.)
5.	Food and nutrition, Malnutrition (over and under nutrition),
6.	Nutritional disorders; Energy metabolism (carbohydrate, fat, proteins)
7.	Balanced/ modified diets, Menu planning,
8.	New trends in food science and nutrition
9.	Enzymes: General properties; Classification; Mechanism of action; Michaelis & Menten and Line Weaver Burk equation & plots; Introduction to allosteric enzymes
10.	Nucleic acids: Importance and classification; Structure of Nucleotides, A, B & Z DNA; RNA: Types and Secondary & Tertiary structure.
11.	Metabolism of carbohydrates: Glycolysis, TCA cycle, Glyoxylate cycle, Electron transport chain.
12.	Metabolism of lipids: Beta oxidation, Biosynthesis of fatty acids.

Department - Soil Science and Agricultural Chemistry

54. SAC – 111 (Fundamentals of Soil Science)

Credit Hours: 3 (2+ 1)

Topics in Theory:

S. No.	Topics
1.	Definitions of Soil, as a natural body, Soil Profile, components of soil;
2.	Pedological and edaphological concepts of soil;
3.	Soil genesis: soil forming rocks and minerals;
4.	Weathering, processes and factors of soil formation
5.	Soil physical properties: soil-texture, structure, density and porosity, soil colour, consistence and plasticity
6.	Elementary knowledge of soil taxonomy classification and soils of India
7.	Soil water retention, movement and availability
8.	Soil air, composition, gaseous exchange, problem and plant growth
9.	Soil temperature; source, amount and flow of heat in soil; effect on plant growth
10.	Soil reaction-pH, soil acidity and alkalinity, buffering
11.	Effect of pH on nutrient availability
12.	Soil colloids - inorganic and organic components
13.	Silicate clays: constitution and properties
14.	Sources of charge; ion exchange,
15.	Cation exchange capacity & base saturation
16.	Soil organic matter: composition, properties and its influence on soil properties
17.	Humic substances - nature and properties
18.	Soil pollution - behaviour of pesticides and inorganic contaminants,
19.	Prevention and mitigation of soil pollution.
20.	Soil organisms: macro and microorganisms, their beneficial and harmful effects.

Topics in Practical:

S. No.	Topics
1.	Study of soil profile in field.
2.	Study of soil sampling tools, collection of representative soil sample, its processing and storage.
3.	Study of soil forming rocks and minerals.
4.	Determination of soil density, moisture content and porosity
5.	Determination of soil texture by feel and Bouyoucos Methods
6.	Studies of capillary rise phenomenon of water in soil column and water movement in soil.
7.	Determination of soil pH and electrical conductivity.

8.	Determination of cation exchange capacity of soil
9.	Study of soil map
10.	Determination of soil colour
11.	Demonstration of heat transfer in soil.
12.	Estimation of organic matter content of soil.

Suggested Readings:

- Baver, L.D. Gardener, W.H. and gardener W.R.(1976) Soil Physics Wiley Eastern Ltd, New Delhi
- Biswas, T.D. and Mukherjee, S.K. (2006) Text book of soil science. Tata McGraw Hill publishing Co. Ltd, New Delhi
- Brady, N.C. and Weil, R.R. (2002) The nature and properties of soils, prentice hall of India Pvt. Ltd, M-97, Connaught Circus, New Delhi
- Das, D.K. (2002) Introductory Soil Science, Kalyani publisher, New Delhi
- ISSS (2009) Fundamentals of Soil Science, Div. of Soil Science, IARI, New Delhi
- Chopra S.L. and Kanwar, J.S. (1991) Analytical Agricultural Chemistry, Kalyani publisher, Ludhiana 64
- Jackson, M.L. (1973) Soil chemical analysis, Prentice Hall of India, Pvt. Ltd New Delhi
- Piper, C.S. (1950) Soil and plant analysis. Hans publications, Bombay
- Richards, L.A. (1960) Diagnosis and improvement of saline and alkali soils., USDA agriculture Hand book 60, Washington D.C., USA
- Agarwal, R.R., Yadav, J.S.P. & Gupta, R.N. (1982) Saline and alkali soils of India. ICAR, New Delhi.
- Sehgal, J. (2000) Pedology: Concepts and applications, Kalyani publisher, Ludhiana

55. SAC – 221 (Problematic Soils and Their Management)

Credit Hours: 2 (2+0)

Topics in Theory:

S. No.	Topics
1.	Soil quality and health
2.	Distribution of Waste land and problem soils in India and their categorization based on properties
3.	Reclamation and management of Saline and sodic soils
4.	Acid soils, Acid Sulphate soils
5.	Eroded and Compacted soils
6.	Flooded soils
7.	Polluted soils
8.	Irrigation water – quality and standards,
9.	Utilization of saline water in agriculture
10.	Remote sensing and GIS in diagnosis and management of problem soils

11.	Multipurpose tree species, bio remediation of soils through MPTs
12.	Land capability and classification,
13.	Land suitability classification
14.	Problematic soils under different Agro-ecosystems

Suggested Readings:

- Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.
- Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology. Utah State Univ.
- USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.
- Abrol, I.P. and Dhurva Narayana, V.V. (1998) Technologies for wasteland development, ICAR, New Delhi-110012
- Cirsan Paul, J.(1985) Principles of remote sensing. Longman, New York.
- Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils. USDA Hand book No. 60, Washington, DC USA.
- Somani, L.L. and Totawat, K.L. (1993). Management of salt affected soils and waters. Agrotech publishing Academy, Udaipur.
- Agarwal, R.R., Yadav, J.S.P. and Gupta, R.N. (1982). Saline Alkali soils of India, ICAR, New Delhi.
- ISSS (2009) Fundamentals of Soil Science, Div. of Soil Science, IARI, New Delhi
- Ganesh, A. (2015). GPS principles and Applications (e-books); Publisher Satish Serials.

56. SAC – 311 (Manures, Fertilizers and Soil Fertility Management)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction and importance of organic manures,
2.	Properties and methods of preparation of bulky and concentrated manures.
3.	Green/leaf manuring.
4.	Fertilizer recommendation approaches.
5.	Integrated nutrient management.
6.	Chemical fertilizers: classification, ,
7.	Composition and properties of major nitrogenous, phosphatic, potassic fertilizers
8.	Secondary & micronutrient fertilizers,
9.	Complex fertilizers, nano fertilizers & Soil amendments,
10.	Fertilizer Storage, Fertilizer Control Order.
11.	History of soil fertility and plant nutrition
12.	Criteria of essentiality, role, deficiency and toxicity symptoms of essential plant nutrients

13.	Mechanisms of nutrient transport to plants,
14.	Factors affecting nutrient availability to plants
15.	Chemistry of soil nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients.
16.	Soil fertility evaluation,
17.	Soil testing. Critical levels of different nutrients in soil
18.	Forms of nutrients in soil, plant analysis, rapid plant tissue tests. Indicator plants
19.	Methods of fertilizer recommendations to crops
20.	Factor influencing nutrient use efficiency (NUE), methods of application under rainfed and irrigated conditions

Topics in Practical:

S. No.	Topics
1.	Introduction of analytical instruments and their principles
2.	Calibration and applications of analytical instruments
3.	Colorimetry and flame photometry
4.	Estimation of soil organic carbon
5.	Estimation of alkaline hydrolysable N in soils
6.	Estimation of soil extractable P in soils
7.	Estimation of exchangeable K; Ca and Mg in soils
8.	Estimation of soil extractable S in soils
9.	Estimation of DTPA extractable Zn in soils
10.	Estimation of N in plants.
11.	Estimation of P in plants
12.	Estimation of K in plants
13.	Estimation of S in plants

Suggested Readings:

- Biswas, T.D. and Mukherjee, S.K. (2006) Text book of soil science.Tata McGraw Hill publishing Co. Ltd, New Delhi
- Das, D.K. (2002) Introductory Soil Science, Kalyani publisher, New Delhi
- Rai, M.M. (2002) Principal of Soil Science, Mac Millan India Ltd, New Delhi
- ISSS (2002) Fundamental of Soil Science Div. of Soil Science, IARI, New Delhi
- Jackson, M.L. (1973) Soil chemical analysis, Prentice Hall of India, Pvt. Ltd New Delhi
- Piper, C.S. (1950) Soil and Plant analysis, .Hans publications, Bombay
- Singh Dhyan, Chhonkar, P.K. and Dwivedi V.S. (2005) Manual on Soil Plant and water analysis. Westville Publishing House, New Delhi
- Tisdale, S.L. Nelson, W.L. Beaton, J.D. and Havlin, J.L.(1991) Soil fertility and fertilizers (5th ed.).Prentice Hall of India, Pvt . Ltd, New Delhi.

- Singh Vinay (1996) (Hindi) Soil Science, fertilizer & Manures , V.K. Prakashan Barot Meerut (U.P)
- Yawalkar, K.S. and Agarwal. J.P. (1992). Manure and fertilizers. Agriculture Horticulture Publishing House, Nagpur.
- Macself, A.J. (2015) Soils and Fertlizers (e-book) Publisher Satish Serial.
- Rajkumar, G. R. (2016). Soil Chemistry, Fertility and Fertlizers (e-book): Publisher Satish Serial

57. SAC – 312 (Bio-pesticides & Bio-fertilizers)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	History and concept of bio-pesticides
2.	Importance, scope and potential of bio-pesticide
3.	Definitions, concepts and classification of bio-pesticides viz. pathogen, botanical pesticides, and bio-rationales
4.	Botanicals and their uses
5.	Mass production technology of bio-pesticides
6.	Virulence, pathogenicity and symptoms of entomopathogenic pathogens and nematodes
7.	Methods of application of bio-pesticides
8.	Methods of quality control and Techniques of bio-pesticides.
9.	Impediments and limitation in production and use of bio-pesticide
10.	Bio-fertilizers - Introduction, status and scope
11.	Structure and characteristic features of bacterial bio-fertilizers- Azo-spirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frakia; Cynobacterial
12.	Bio-fertilizers- Anabaena, Nostoc, Hapalosiphon and fungal biofertilizers- AM mycorrhiza and ectomycorhiza.
13.	Nitrogen fixation -Free living and symbiotic nitrogen fixation.
14.	Mechanism of phosphate solubilization and phosphate mobilization, K solubilization.
15.	Production technology: Strain selection, sterilization, growth and fermentation,
16.	Mass production of carrier based and liquid bio-fertilizers.
17.	FCO specifications and quality control of bio-fertilizers
18.	Application technology for seeds, seedlings, tubers, sets *etc*.
19.	Bio-fertilizers -Storage, shelf life, quality control and marketing.
20.	Factors influencing the efficacy of bio-fertilizers

Topics in Practical:

S. No.	Topics
1.	Isolation and purification of important bio-pesticides
2.	Trichoderma Pseudomonas, Bacillus, Metarhyzium etc. and its production

3.	Identification of important botanicals.
4.	Visit to biopesticide laboratory in nearby area.
5.	Field visit to explore naturally infected cadavers
6.	Identification of entomo-pathogenic entities in field condition. Quality control of bio-pesticides.
7.	Isolation and purification of Azospirillum , Azotobacter, Rhizobium, P-solubilizers and cyanobacteria
8.	Mass multiplication and inoculums production of bio-fertilizers
9.	Isolation of AM fungi -Wet sieving method and sucrose gradient method
10.	Mass production of AM inoculants

Suggested Readings:

- Lakshman, H.C. (2014) Bio-fertilizers and Bio-pesticides. Pointer Publishers
- Sylvia D.N. 2005; Principles and application of Soil Microbiology. Peason Publisher.
- Project Directorate of Biological control. 1994. Technology for mass production of natural enemies. Technical Bulletin-4.
- Rabindra, R.J., Kennedy, J.S., Sathaiah, N., Rajeshkharan, B. and Srinivasan, M.R. 2001. Microbial control of crop pests. TNAU.
- Dhaliwal, GS & Koul O. 2007. Biopesticides and pest management. Kalyani Publ., New Delhi

Department - Veterinary Science and Animal Husbandry

58. LPM – 211 (Livestock and Poultry Management)

Credit Hours: 4 (3+1)

Topics in Theory:

S. No.	Topics
1.	Role of livestock in the national economy
2.	Important Indian breeds of cattle
3.	Important exotic breeds of cattle
4.	Important breeds of buffalo
5.	Important Indian breeds of sheep and goat
6.	Important exotic breeds of sheep and goat
7.	Important Indian and exotic breeds of swine
8.	Important Indian and exotic breeds of poultry
9.	Reproduction in farm animals and poultry
10.	Housing principles, space requirements for different species of livestock
11.	Housing principles, space requirements for different species of poultry
12.	Management of calves and growing heifers
13.	Management of milch animals
14.	Management of sheep and goat
15.	Management of swine
16.	Incubation and hatching of eggs
17.	Brooding of chicks
18.	Management of growers and layers
19.	Improvement of farm animals and poultry
20.	Digestion in livestock
21.	Digestion in poultry
22.	Classification of feedstuffs
23.	Proximate principles of feed
24.	Nutrients and their functions
25.	Feed ingredients for ration for livestock and poultry
26.	Feeding of livestock and poultry. Feed supplements and feed additives
27.	Introduction of livestock diseases
28.	Introduction of poultry diseases
29.	Prevention (including vaccination schedule) and control of important diseases of livestock
30.	Prevention (including vaccination schedule) and control of important diseases of poultry

Topics in Practical:

S. No.	Topics
1.	Visit to IDF and IPF to study breeds of livestock and poultry and daily routine farm operations and farm records
2.	External body parts of cattle, buffalo, sheep, goat, swine and poultry
3.	Identification methods of farm animals and poultry
4.	Computation of rations for livestock. Formulation of concentrate mixtures
5.	Handling and restraining of livestock
6.	Judging of cattle, buffalo and poultry
7.	Culling of livestock and poultry
8.	Planning and layout of housing for different types of livestock
9.	Clean milk production, milking methods
10.	Hatchery operations, incubation and hatching equipments
11.	Management of chicks, growers and layers
12.	Debeaking, dusting and vaccination
13.	Economics of cattle, buffalo, sheep, goat, swine and poultry production

Suggested Readings:

- Livestock Production Management (N.S.R. Sastry and C.K. Thomas)
- A Text Book of Animal Husbandry (G.C. Banerjee)
- Poultry Production (R.A. Singh)
- Animal Husbandry (Harbansh Singh and Moore)
- Animal Husbandry and Dairying (Jagdish Prasad)
- Principles and practices of dairy farm management (Jagdish Prasad and Neeraj)
- Poultry (G. C. Benerjee)

Department - English Language

59. ENG – 111 (Comprehension and Communication Skills in English

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	War Minus Shooting- The sporting Spirit. A Dilemma- A layman looks at science Raymond
2.	B. Fosdick. You and Your English – Spoken English and broken English G.B. Shaw
3.	Reading Comprehension, Vocabulary- Antonym, Synonym, Homophones, Homonyms, often confused words
4.	Exercises to Help the students in the enrichment of vocabulary based on TOEFL and other competitive examinations. Functional grammar
5.	Articles, Prepositions, Verb, Subject verb Agreement, Transformation, Synthesis, Direct and Indirect Narration
6.	Written Skills: Paragraph writing
7.	Precise writing, Report writing and Proposal writing The Style:
8.	Importance of professional writing
9.	Preparation of Curriculum Vitae and Job applications
10.	Synopsis Writing
11.	Interviews: kinds, Importance and process.

Topics in Practical:

S. No.	Topics
1.	Listening Comprehension: Listening to short talks lectures, speeches (scientific, commercial and general in nature)
2.	Oral Communication: Phonetics, stress and intonation, Conversation practice
3.	Conversation: rate of speech, clarity of voice, speaking and Listening
4.	Politeness & Reading skills
5.	Reading dialogues, rapid reading
6.	Intensive reading, improving reading skills
7.	Mock Interviews: testing initiative
8.	Team spirit, leadership, intellectual ability
9.	Group Discussions

Suggested Readings:

- Balasubramanian T. 1989. *A Text book of Phonetics for Indian Students*, Orient Longman , New Delhi
- Balasubrmanyam M. 1985. *Business Communication*, Vani Educational Books, New Delhi
- Jean Naterop, B. and Rod Revell 1997. *Telephoning in English* Cambridge University Press,

NON-GRADIAL COURSES

I. NSS/NCC/Physical Education & Yoga Practices 2(0+2)

Semester I

61. Course Title: National Service Scheme I

Introduction and basic components of NSS:

Orientation: History, objectives, principles, symbol, badge; regular programmes under NSS, organizational structure of NSS, code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.

NSS programmes and activities

Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analysing guiding financial patterns of scheme, youth programme/ schemes of GOI, coordination with different agencies and maintenance of diary

Understanding youth

Definition, profile, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change

Community mobilization

Mapping of community stakeholders, Designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership

Social harmony and national integration

Indian history and culture, role of youth in nation building, conflict resolution and peace-building

Volunteerism and shramdan

Indian tradition of volunteerism, its need, importance, motivation and constraints; shramdan as part of volunteerism

Citizenship, constitution and human rights

Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information

Family and society

Concept of family, community (PRIs and other community-based organizations) and society

Semester II

62. Course Title: National Service Scheme II

Importance and role of youth leadership

Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership

Life competencies

Definition and importance of life competencies, problem-solving and decision-making, inter personal communication

Youth development programmes

Development of youth programmes and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations

Health, hygiene and sanitation

Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programmes and reproductive health.

Youth health, lifestyle, HIV AIDS and first aid

Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid

Youth and yoga

History, philosophy, concept, myths and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method

Semester III

63. Course Title: National Service Scheme III

Vocational skill development

To enhance the employment potential and to set up small business enterprises skills of volunteers, a list of 12 to 15 vocational skills will be drawn up based on the local conditions and opportunities. Each volunteer will have the option to select two skill-areas out of this list

Issues related environment

Environmental conservation, enrichment and sustainability, climatic change, natural resource management (rain water harvesting, energy conservation, forestation, waste land development and soil conservations) and waste management

Disaster management

Introduction and classification of disaster, rehabilitation and management after disaster; role of NSS volunteers in disaster management.

Entrepreneurship development

Definition, meaning and quality of entrepreneur; steps in opening of an enterprise and role of financial and support service institution.

Formulation of production-oriented project

Planning, implementation, management and impact assessment of project

Documentation and data reporting

Collection and analysis of data, documentation and dissemination of project reports

Semester IV

64. Course Title: National Service Scheme IV

Youth and crime

Sociological and psychological factors influencing youth crime, cybercrime, pear mentoring in preventing crime and awareness for juvenile justice

Civil/self defense

Civil defense services, aims and objectives of civil defense; needs and training of self defense

Resource mobilization

Writing a project proposal of self-fund units (SFUs) and its establishment

Additional life skills

Positive thinking, self-confidence and esteem, setting life goals and working to achieve them, management of stress including time management.

Semester I

65. Course Title: National Cadet Corps

1. Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
2. Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
3. Sizing, numbering, forming in three ranks, open and close order march and dressing.
4. Saluting at the halt, getting on parade, dismissing and falling out.
5. Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear.
6. Turning on the march and wheeling. Saluting on the march.
7. Marking time, forward march and halt.
8. Changing step, formation of squad and squad drill.
9. Command and control, organization, badges of rank, honors and awards
10. Nation Building- cultural heritage, religions, traditions and customs of India. National integration.
11. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizen.
12. Leadership traits, types of leadership. Character/personality development.
13. Civil defense organization, types of emergencies, firefighting, protection,
14. Maintenance of essential services, disaster management, aid during development projects. 15. Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
15. Structure and function of human body, diet and exercise, hygiene and sanitation.
16. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health.
17. Adventure activities
18. Basic principles of ecology, environmental conservation, pollution and its control.
19. Precaution and general behaviour of girl cadets, prevention of untoward incidents, vulnerable parts of the body, self-defense.

References	
Cadet Hand Book (Army Wing)	Major R.C. Mishra
Cadet Hand Book (Army Wing)	Directorate General, NCC, Ministry of Defense, R.K. Puram, New Delhi

Semester II

66. Course Title: National Cadet Corps

1. Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms.
2. Shoulder from the order and vice-versa, present from the order and vice-versa.
3. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice-versa.
4. Guard mounting, guard of honor, Platoon/Coy Drill.

PROGRAMME-2

B.Sc. (Hons.)

Horticulture

Department – Basic Sciences

1. PBC – 121 (Elementary Plant Biochemistry)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Carbohydrates: Occurrence, classification and structure, physical and chemical properties of carbohydrates, isomerism, optical activity, reducing property, reaction with acids and alkalis, ozone formation.
2.	Lipids: Classification, important fatty acids and triglycerides, essential fatty acids. Physical and chemical properties of oils, rancidity, phospholipids, types and importance.
3.	Plant pigments – structure and function of chlorophyll and carotenoids.
4.	Sterols, basic structure, role of brassino sterols in plants.
5.	Proteins: Classification, function and solubility, amino acids – classification and structure, essential amino acids, properties of amino acids, colour reactions, amphoteric nature and isomerism; structure of proteins –primary, secondary tertiary and quaternary structure and reaction of proteins.
6.	Enzymes: Classification and mechanism of action; factors affecting enzyme action
7.	Coenzymes and co-factors.
8.	Vitamins and minerals as co-enzymes/co-factors.
9.	Carbohydrate metabolism – glycolysis and TCA-cycle;
10.	Metabolism of lipids, biosynthesis of fatty acids, fatty acid oxidation
11.	Electron transport chain, bioenergetics of glucose and fatty acids
12.	Structure and function of nucleic acid, replication, transcription and translation.

Topics in Practical:

S. No.	Topics
1.	Preparation of standard solutions and reagents
2.	Carbohydrates: Qualitative reactions and test
3.	Estimation of starch; Estimation of reducing and non-reducing sugars from fruits
4.	Amino acids: Reactions of amino acids
5.	Proteins: Estimation of proteins by Lowry's method
6.	Fatty acids: Estimation of free fatty acids, acid value determination
7.	Determination of iodine number of vegetable oils
8.	Vitamins: Estimation of Ascorbic acid
9.	Techniques: Paper chromatography
10.	Thin layer chromatography
11.	Electrophoresis of pigments extracted from flowers
12.	Extraction of oil from oil seeds

13.	Enzymes: Enzyme assay, Enzyme

Suggested Readings:

- Lehninger, Nelson, D. L. and Michael, M. C. 2004. *Principles of Biochemistry.* Freeman Publishers
- Narayanan L M. Biochemistry. Saras Publications.
- Bose. Developments in Physiology Biochemistry & Molecular Biology of Plants Vol.-1. New India Publications.689
- Voet, D and Voet J. G. 2004. Biochemistry 4th Edition. Wiley & sons Publishers. USA.
- Sadashiv, S and Manickam, A. 1996. Biochemical methods for Agricultural sciences. New age International Publishers, New Delhi.
- Voet, D. and Voet, J.G. 2004. (3rd edit). Biochemistry. John Wiley & sons Incl.USA.
- Rameshwar, A. 2006. (3rd edit). Practical Biochemistry. Kalyani Publishers, New Delhi.
- Buchanan, B. B., Gruissem, W. and Jones, R. L. 2002. Biochemistry and molecular biology of plants. 2nd edition. Blackwell publications, UK.

2. EPB – 221 (Elementary Plant Biotechnology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Concepts of Plant Biotechnology
2.	History of Plant Tissue Culture and Plant Genetic Engineering; Scope and importance in Crop Improvement
3.	Totipotency and Morphogenesis
4.	Nutritional requirements of in-vitro cultures
5.	Techniques of In-vitro cultures
6.	Micro propagation
7.	Anther culture and Pollen culture
8.	Ovule culture and Embryo culture
9.	Test tube fertilization, Endosperm culture, Factors affecting above in-vitro culture
10.	Applications and Achievements; Somaclonal variation, Types, Reasons: Somatic embryogenesis and synthetic seed production technology
11.	Protoplast isolation, Culture, Manipulation and Fusion; Products of somatic hybrids and cybrids
12.	Applications in crop improvement. Genetic engineering; Restriction enzymes; Vectors for gene transfer – Gene cloning – Direct and indirect method of gene transfer
13.	Transgenic plants and their applications. Blotting techniques
14.	DNA finger printing – DNA based markers – RFLP, AFLP, RAPD, SSR and DNA Probes – Mapping QTL – Future prospects. MAS, and its application in crop improvement.
15.	Nanotechnology: Definition and scope, types of nano material and their synthesis, green

	synthesis.
16.	Tools and techniques to characterize the nano particles. Nano-biotechnological applications with examples, Nano toxicology and safety.

Topics in Practical:

S. No.	Topics
1.	Requirements for Plant Tissue Culture Laboratory; Techniques in Plant Tissue Culture; Media components and preparations;
2.	Sterilization techniques and Inoculation of various explants; Aseptic manipulation of various explants;
3.	Callus induction and Plant Regeneration; Micro propagation of important crops; Anther, Embryo and Endosperm culture;
4.	Hardening / Acclimatization of regenerated plants;
5.	Somatic embryogenesis and synthetic seed production; Isolation of protoplast;
6.	Demonstration of Culturing of protoplast
7.	Demonstration of Isolation of DNA;
8.	Demonstration of Gene transfer techniques, (direct methods ;)
9.	Demonstration of Gene transfer techniques, indirect methods ;)
10.	Demonstration of Confirmation of Genetic transformation;
11.	Demonstration of gel electrophoricsis techniques.
12.	Green synthesis of nano particles and their size characterization.

Suggested Readings:

- Singh, B D, 2004. Biotechnology Expanding Horizons 2nd Edn. Kalyani Publishers, New
- Delhi.
- Gupta, P.K., 2015. Elements of Biotechnology 2nd Edn. Rastogi and Co., Meerut.
- Razdan M K, 2014. Introduction to plant Tissue Culture 2nd Edn. Science Publishers, Inc. USA.
- Gautam V K, 2005. Agricultural Biotechnology. Sublime Publications
- Thomar, R.S., Parakhia, M.V., Patel, S.V. and Golakia, B.A., 2010. Molecular markers and Plant Biotechnology, New Publishers, New Delhi.
- Purohit, S.S., 2004. A Laboratory Manual of Plant Biotechnology 2nd Edn. Agribios, India.
- Singh, B.D. 2012. Plant Biotechnology. Kalyani publishers, Ludhiana
- Bilgrami, K.S. and Pandey, A.K.1992. Introduction to Biotechnology. CBS Pub. New Delhi
- Gupta, P.K. 1994. Elements of Biotechnology. Rastogi Pub. Meerut.
- Chahal, G.S. and Gosal, S.S.2003. Principles and Procedures of Plant Approaches Breeding
- Biotechnological and Conventional. Narosa Publishing House, New Delhi

3. STAT – 111 (Elementary Statistics and Computer Application)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to statistics, limitations of statistics. Basic concepts: Variable statistics, types and sources of data, classification and tabulation of data,
2.	Construction of frequency distribution, tables, graphic representation of data, simple, multiple component and percentage
3.	Bar diagram, pie diagram, histogram,
4.	Frequency polygon and frequency curve
5.	Average and measures of location, mean, mode, median,
6.	Geometric mean, harmonic mean, percentiles and quartiles for raw and grouped data.
7.	Dispersion: Range, standard deviation, variance,
8.	Coefficient of variation for raw and grouped data.
9.	Probability: Basic concept, additive and multiplicative laws.
10.	Theoretical distributions, binominal, poison and normal distributions, sampling, basic concepts, sampling v/s. complete enumeration parameter
11.	Statistical sampling methods, simple random sampling and stratified random sampling.
12.	Tests of Significance: Basic concepts, tests for equality of means, and independent and paired t-tests,
13.	Chi-square test for application of attributes and
14.	Test for goodness of fit of Mendalian ratios.
15.	Correlation: Scatter diagram, correlation co-efficient and its properties,
16.	Regression, fitting of simple linear regression, test of significance of correlation and regression coefficient.
17.	Experimental designs: Basic concepts, completely randomized design, randomized block design, latin square designs,
18.	Factorial experiments, basic concepts, analysis of factorial experiments up to 3 factors
19.	Split plot design, strip plot design, long term experiments, plot size, guard rows.
20.	Computer application: Introduction to computers and personal computers, basic concepts, operating system, DOS and Windows, MS Word- Features of word processing, creating document and tables and printing of document,
21.	MS Excel-Concept of electronic spreadsheet, creating, editing and saving of spreadsheet, inbuilt statistical functions and formula bar, MS Power point-preparation, presentation of slides and slide show.
22.	Introduction to programming languages, BASIC language, concepts, basic and programming techniques, MS Office, Win Word, Excel,
23.	Power point, introduction to multi-media and its application.
24.	Visual basic-concepts, basic and programming techniques, introduction to internet.

Topics in Practical:

S. No.	Topics

1.	Construction of frequency distribution table and its graphical representation, histogram, frequency polygon, frequency curve.
2.	Bar chart, simple, multiple, component and percentage bar charts, pie chart
3.	Mean, mode, percentiles, quartile and median for row and grouped data
4.	Coefficient of variation.
5.	't' test for independent, will equal and unequal variants, paired 't' test.
6.	Chi-square test for contingency tables and theoretical ratios.
7.	Correlation and linear regression.
8.	Studies on computer components–Basic language, visual basic, programming techniques.
9.	MS Office, Excel, power point

Suggested Readings:

- Gupta, S. C. and Kapoor, V. K. 2014. Fundamentals of Mathematical Statistics. Sultan Chand and sons. New Delhi
- Nageswara Rao, G. 2007.Statistics for Agricultural Sciences. B.S. Publications, Hyderabad.
- Rangaswamy, R.1995. A Text Book of Agricultural Statistics. New Age International Publishing Limited, Hyderabad.
- Gupta, V.,2002. Comdex Computer Kit. Dream Tech Press, New Delhi.
- Parmar, A. Mathur, N. Deepti P .U. and Prasanna, V. B.,2000.WorkingwithWINDOWS A Handson Tutorials. Tata Mc Graw Hill Publishing Co., New Delhi.
- Bandari, V. B., 2012. Fundamentals of Information Technology. Pearson Education, New Delhi.
- Fundamentals of Computers. 2011. Pearson Education-ITL ESL, New Delhi

4. EVS – 111 (Introductory Crop Physiology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Water Relations in Plants: Role of water in plant metabolism, osmosis imbibition, diffusion, water potential and its components, measurement of water potential in plants.
2.	Absorption of water, mechanism of absorption and ascent of sap.
3.	Stomata: Structure, distribution, classification, mechanism of opening and closing of stomata.
4.	Osmotic pressure, guttation, stem bleeding; transpiration methods and mechanism and factors affecting transpiration
5.	Drought: Different types of stresses; water, heat and cold tolerance; mechanism of tolerance.
6.	Plant Nutrition: Essentiality, mechanism of absorption and its role in plant metabolism. Biological nitrogen fixation
7.	Photosynthesis, structure and function of chloroplast, dark and light reactions, cyclic and

	non-cyclic electron transfer, Co_2 fixation – C3, C4 and CA metabolism, advantages of C4 pathway. Photorespiration and its implications, factors affecting photosynthesis.
8.	Mode of herbicide action, Secondary metabolites and plant defence.

Topics in Practical:

S. No.	Topics
1.	Measurement of water potential, osmosis, root pressure.
2.	Structure of the stomata, distribution, opening and closing of the stomata.
3.	Measurement, transpiration and calculation of transpirational pull demonstration.
4.	Importance of light and chlorophyll in photosynthesis.
5.	Pigment identification in horticultural crops.
6.	Measurement of relative water content (RWC).
7.	Studying plant movements.

Suggested Readings:

- Salisbulry. 2007. *Plant Physiology.* CBS. New Delhi.
- Taiz, L. 2010.Plant Physiology. SINAUR. USA.
- Zeiger. 2003.Plant Physiology. PANIMA. New Delhi.
- Edward E. Durna. 2014. Principles Of Horticultural Physiology. CABI, UK.
- Delvin, R.M . 1986. Plant Physiology. CBS. Delhi.
- Richard, N. Arteca. 2004. Plant Growth Substances. CBS. New Delhi.
- Jacobs, W. P. 1979. Plant Hormones and Plant Development. Cambridge Univ. London.
- Basra, A. S. 2004. Plant Growth Regulators in Agriculture & Horticulture. HAWARTH Press. New York.
- Lincoln Taiz and Eduards Zeiger (5th Edition). Plant physiology
- Noggle G.R and Fritz T.G. Introductory Plant Physiology
- Pandey and Sinha. Plant Physiology Salisbury and Ross. Plant Physiology 69
- Carl Fedtke. Biochemistry and Physiology of Herbicide Action
- Aswani Pareek, S.K. Sopory, Hans Bohnert Govindjee. Abiotic stress adaptation in plants:
- Physiological, Molecular and Genomic foundation
- Horst Marschner, Mineral Nutrition of Higher plants

5. FSC – 123 (Growth and Development of Horticultural Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Growth and development-definitions, components, photosynthetic productivity, Canopy photosynthesis and productivity, leaf area index (LAI) - optimum LAI in horticultural

	crops
2.	Canopy development; different stages of growth, growth curves, Crop development and dynamics (Case studies of annual/perennial horticultural crops), growth analysis in horticultural crops
3.	Plant bio-regulators- auxin, gibberellin, cytokinin, ethylene inhibitors and retardants, basic functions, biosynthesis, role in crop growth and development, propagation, flowering, fruit setting, fruit thinning, fruit development, fruit drop, and fruit ripening
4.	Flowering-factors affecting flowering, physiology of flowering, photoperiodism-long day, short day and day neutral plants,
5.	Vernalisation and its application in horticulture, pruning and training physiological basis of training and pruning-source and sink relationship, translocation of assimilates.
6.	Physiology of seed development and maturation, seed dormancy and bud dormancy, causes and breaking methods in horticultural crops.
7.	Physiology of fruit growth and development, fruit setting, factors affecting fruit set and development,
8.	Physiology of ripening of fruits-climatic and non-climacteric Fruits. Physiology of fruits under post-harvest storage.

Topics in Practical:

S. No.	Topics
1.	Estimation of photosynthetic potential of horticultural crops, leaf area index, growth analysis parameters including harvest index
2.	Bioassay of plant hormones, identification of synthetic plant hormones and growth retardants
3.	Preparations of hormonal solution and induction of rooting in cuttings, ripening of fruits and control of flower and fruit drop
4.	Important physiological disorders and their remedial measures in fruits and vegetables
5.	Seed dormancy, seed germination and breaking seed dormancy with chemicals and growth regulators

Suggested Readings:

- Salisbulry. 2007. Plant Physiology. CBS. New Delhi.
- Taiz, L. 2010.Plant Physiology. SINAUR. USA.
- Zeiger. 2003.Plant Physiology. PANIMA. New Delhi.
- Edward E. Durna. 2014. Principles of Horticultural Physiology. CABI, UK.
- Delvin, R.M . 1986. Plant Physiology. CBS. Delhi.
- Richard, N. Arteca. 2004. Plant Growth Substances. CBS. New Delhi.
- Jacobs, W. P. 1979. Plant Hormones and Plant Development. Cambridge Univ. London.
- Basra, A. S. 2004. Plant Growth Regulators in Agriculture & Horticulture. HAWARTH press. New York.
- Lincoln Taiz and Eduards Zeiger (5th Edition). Plant physiology. Sinauer Associates, Inc.

- Noggle G.R and Fritz T.G.1944. Introductory Plant Physiology.
- Pandey and Sinha. Plant Physiology.692
- JKA Bleasdale, Plant Physiology in relation to Horticulture
- Amarjit Basra, Plant Growth Regulators in Agriculture and Horticulture: Their role &Commercial Uses
- Rajendran, Ramamoorthy and S. Juliet Hepziba, Nutritional and Physiological Disorders in Crop Plants

6. PPT – 111 (Introductory Microbiology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	History and Scope of Microbiology
2.	The discovery of micro-organism, spontaneous generation conflict, germ theory of diseases, microbial effect on organic and inorganic matter.
3.	Development of microbiology in India and composition of microbial world.
4.	Microscopy and Specimen Preparation: The bright field microscope, fixation, dyes and simple staining, differential staining.
5.	Difference between prokaryotic and eukaryotic cells. Prokaryotic cell structure and functions. Plant pathogenic bacteria
6.	Types of culture media and pre-culture techniques. Microbial growth in models of bacterial, yeast and mycelial growth curve. Measurement of bacterial growth
7.	General properties of viruses and brief description of bacterophages.
8.	DNA as genetic material.
9.	Antibiosis, symbiosis, intramicrobial and extra-microbial association
10.	Sterilization methods- physical and chemical, isolation of pure cultures and preservation of cultures
11.	Plant growth promoting microorganisms
12.	Mushrooms- economical importance, mushrooms edible and poisonous type, nutritive values, culturing and production techniques.
13.	Industrially important microorganism in large scale production and common microbial fermentations.

Topics in Practical:

S. No.	Topics
1.	Examination of natural infusion and living bacteria
2.	Examination of stained cells by simple staining and gram staining
3.	Method for sterilization and nutrient agar preparation
4.	Broth culture, agar slopes, streak plates and pour plats, turbid metric estimation of

	microbial growth.
5.	Mushroom culture-spawns production, culture and production techniques, harvesting packing and storage.

Suggested Readings:

- M T Madigan, and J M Martinko, 2014. Brock Biology of Microorganisms 14th Edn. Pearson.
- M J Pelczer, 1998. Microbiology 5th Edn. Tata Mc. Grow Hill Education Pvt. Ltd.
- Stainer, R, 1987. General Microbiology. Palgrave Macmillan.
- Edward Alchano, 2002. Introduction to Microbiology. Jones and Bartlett hearing.
- R P Singh, 2007. General Microbiology. Kalyani Publishers.
- J Heritage, E G V Evans, R A Killington, 2008. Introductory Microbiology. Cambridge University press P. date.
- Pelczar, jr. M.J.E.C.S. Chan and Krieg, N.R. 1996. Microbiology. Mc Graw Hill Publishers, New York.
- Prescott, L.M. Harley, J.P. and Klein, D.A (5ed) 2002. Microbiology. Mc Graw Hill Publishers, Newyork.

Department – Fruit Science

7. FSC – 112 (Plant Propagation and Nursery Management)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Propagation: Need and potentialities for plant multiplication
2.	Sexual and asexual methods of propagation, advantages and disadvantages
3.	Seed dormancy, types of dormancy, internal and external factors, breaking of dormancy (scarification & stratification)
4.	Apomixes – mono-embrony, polyembrony, chimera& bud sport
5.	Propagation Structures: Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, phytotrons nursery (tools and implements)
6.	Use of growth regulators in seed dormancy, types and stages of seed germination with examples and vegetative propagation
7.	Methods and techniques of division-stolons, pseudobulbs, offsets, runners, cutting, layering, grafting, formation of graft union, factor affecting, healing of graftage and budding physiological & bio chemical basis of rooting
8.	Factors influencing rooting of cuttings, layering and graft incompatibility
9.	Anatomical studies of bud union
10.	Selection and maintenance of mother trees, collection of scion wood stick, scion-stock relationship, and their influences, bud wood certification
11.	Techniques of propagation through specialized organs, corm, runners, suckers
12.	Micrografting, meristem culture, callus culture, anther culture, organogenesis, somaclonal variation hardening of plants in nurseries
13.	Nursery registration act
14.	Insect/pest/disease control in nursery, Cost of establishment of propagation structures.

Topics in Practical:

S. No.	Topics
1.	Media for propagation of plants in nursery beds, potting and repotting
2.	Preparation of nursery beds and sowing of seeds
3.	Raising of rootstock. Seed treatments for breaking dormancy and inducing vigorous seedling growth
4.	Preparation of plant material for potting, Hardening plants in the nursery
5.	Practicing different types of cuttings, layering, graftings and buddings including opacity and grafting, top grafting and bridge grafting etc.
6.	Use of mist chamber in propagation and hardening of plants, Preparation of plant growth regulators for seed germination and vegetative propagation
7.	Visit to a tissue culture laboratory

8.	Digging, labelling and packing of nursery fruit plants. Maintenance of nursery records
9.	Use of different types of nursery tools and implements for general nursery and virus tested plant material in the nursery
10.	Cost of establishment of a mist chamber, greenhouse, glasshouse, polyhouse and their maintenance
11.	Nutrient and plant protection applications during nursery

Suggested Readings:

- Hudson T. Hartmann, Dale E. Kester, Fred T. Davies, Jr. and Robert L. Geneve. Plant Propagation- Principles and Practices (7th Edition). PHI Learning Private Limited, New Delhi-110001
- T. K. Bose, S. K. Mitra, M. K. Sadhu, P. Das and D. Sanyal. 2005. Propagation of Tropical & Subtropical Horticultural Crops, Volume 1(3rd Revised edition). Naya Udyog, 206, Bidhan Sarani, Kolkata 700006
- Guy W. Adriance and Feed R. Brison. Propagation of Horticultural Plant. Axis Books (India).
- S. Rajan and B. L. Markose (series editor Prof. K. V. Peter). Propagation of Horticultural Crops-Horticulture Science Series vol.6. New India Publishing Agency, Pitam Pura, New Delhi-110088.
- Hartman, H. T. and Kester, D. E. Plant Propagation Principles and practices. 1976. Prentice hall of India Pvt. Ltd., Bombay
- Sadhu, M.K.1996. Plant Propagation. New age International Publishers, New Delhi.
- Mukhergee, S. K. and Majumdar, P. K. 1973. Propagation of fruit crops. ICAR, New Delhi.
- Ganner, R.J. and Choudhri, S.A. 1972. Propagation of Tropical fruit trees, . Oxford and IBN publishing Co., New Delhi.
- Sarma, R. R. 2002. Propagation of Horticultural Crops. Kalyani Publishers,(Principles and practices) New Delhi.
- Symmonds, 1996. Banana, .II edition, Longman, London.
- Chundawat, B.S. . 1990. Arid fruit culture. Oxford and IBH, New Delhi
- Chadha, K.L. 2002. Hand book of Horticulture. (ICAR), ICAR, New Delhi.

8. FSC – 111 (Fundamentals of Horticulture)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Scope and importance, classification of horticultural crops, branches of horticulture, general features of horticulture
2.	Nutritive value: Functions of fruits and vegetables in human body, importance and role of essential minerals and vitamins for human body, difference between fruits and vegetables
3.	Area and production, exports and imports, research organisations in India
4.	Fruit and vegetable zones of India and of different states, and classification of

	horticultural crops based on different criteria
5.	Nursery techniques and their management, soil and climate
6.	Propagation -Definition, need, sexual and asexual/vegetative method of propagation and their advantages and disadvantages, different vegetative methods of propagation of plants and their merits and demerits
7.	vegetable gardens, nutrition and kitchen garden and other types of gardens Guidelines/principles/importance and layout in planning vegetable gardens
8.	planting systems, planting densities and management of orchards
9.	Objective of orchard management, Resources for better comprehension of orchard management and their advantages and disadvantages
10.	Production and practices for fruit, vegetable and floriculture crops: selection of crop, soil and climate, suitable variety(ies), field preparation, spacing, manuring and fertilizers, plant protection aids, harvesting
11.	Types and methods of pruning and training of fruit crops, factors to be considered in pruning strategy for pruning, frame pruning, maintenance pruning, renewal pruning
12.	Plant growth Regulators -Definition of plant growth regulator, significance of growth regulator, types of phytohormones, role of growth regulators in horticultural crops, method of application of growth regulators
13.	Water management: why plants need application of water, definition of irrigation, Factors affecting the supply of irrigation water to plants, time of irrigation, how much to irrigate, different systems of irrigation and their merits and demerits
14.	Weed management -Definition of weed, commonly observed weed species (monocot/dicot), Methods of weed control, Losses caused by weeds, integrated weed management
15.	fertility management in horticultural crops: organic and inorganic fertilizers, time of application, different methods of fertilizer application
16.	Cropping systems, intercropping, multi-tier cropping, mulching– objectives, types merits and demerits
17.	Classification of bearing habits of fruit trees, factors influencing the fruitfulness and unfruitfulness
18.	Concept of rejuvenation of old orchards, why rejuvenation need in old orchards, top working, frame working
19.	Introduction of organic farming, principles of organic farming, steps involve in market chain management

Topics in Practical:

S. No.	Topics
1.	Features of orchard
2.	Planning and layout of orchard
3.	Tools and implements used for intercultural practices for orchard
4.	Identification of various horticultural crops

5.	Layout of nutrition garden
6.	Preparation of nursery beds for sowing of vegetable seeds
7.	Digging of pits for fruit plants
8.	Planting systems
9.	Training and pruning of orchard trees
10.	Preparation of fertilizer mixtures and field application
11.	Preparation and application of growth regulators
12.	Layout of different irrigation systems
13.	Identification and management of nutritional disorder in fruits
14.	Assessment of bearing habits
15.	Maturity standards
16.	Harvesting, grading, packaging and storage

Suggested Readings:

- Prasad and Kumar, 2014. Principles of Horticulture, 2nd Edn, Agrobios (India).
- Neeraj Pratap Singh, 2005. Basic concepts of Fruit Science 1st Edn, IBDC Publishers.
- Gardner/Bardford/Hooker. J.R., 1957. Fundamentals of Fruit Production, Mac Graw Hill Book Co., New York.
- Edmond, J.B, Sen, T.L, Andrews, F.S and Halfacre R.G, 1936. Fundamentals of Horticulture, 1963Tata Mc Graw Hill Publishing Co., New Delhi.
- Kumar, N, 1990. Introduction to Horticulture, Rajyalakshmi publications, Nagarcoil, Tamilnadu.
- Jitendra Singh, Basic Horticulture, 2002. Kalyani Publishers, Hyderabad.
- Denisen E.L., 1957. Principles of Horticulture, MacMillan Publishing Co., New York.
- Chadha, K.L., 2002. Handbook of Horticulture, (ICAR), ICAR, New Delhi.
- K.V. Peter, 2009. Basics Horticulture, New India Publishing Agency.
- Kausal Kumar Misra and Rajesh Kumar, 2014. Fundamentals of Horticulture, Biotech Books.
- D.K. Salunkhe and S.S. Kadam, 2013. A handbook of Fruit Science and Technology, CRC Press.
- S. Prasad and U. Kumar, 2010. A handbook of Fruit Production, Agrobios (India).
- Jitendra Singh. 2011. Basic Horticulture, Kalyani Publications, New Delhi.

9. FSC – 124 (Tropical and Subtropical Fruits)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Horticultural classification of fruits including genome classification, Horticultural zones of India
2.	Mango: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural

	techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
3.	Banana: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
4.	Grapes: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
5.	Citrus: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning. Management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
6.	Papaya: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
7.	Sapota: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
8.	Guava: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
9.	Pomegranate: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
10.	Bael and Ber: Detailed study of area, production and export potential, varieties, climate

	and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
11.	Aonla and Annona: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
12.	Fig and Pineapple: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
13.	Jackfruit and Avocado: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
14.	Mangosteen and Litchi: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
15.	Carambola and Durian: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
16.	Rambutan and Bilimbi: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
17.	Loquat and Rose apple: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards. Physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage

18.	Breadfruit and Passion fruit: Detailed study of area, production and export potential, varieties, climate and soil requirements, propagation techniques, planting density and systems, after care, training and pruning, management of water, nutrient and weeds, special horticultural techniques including plant growth regulators, their solution preparation and use in commercial orchards, physiological disorders, post-harvest technology, harvest indices, harvesting methods, grading, packaging and storage
19.	Bearing in mango and citrus, causes and control measures of special production problems, alternate and irregular bearing overcome, control measures
20.	Seediness and kokkan disease in banana, citrus decline and casual factors and their management
21.	Bud forecasting in grapes, sex expression and seed production in papaya, latex extraction and crude papain production, economics of production

Topics in Practical:

S. No.	Topics
1.	Description and identification of varieties based on flower and fruit morphology in Mango, banana, grapes, citrus, papaya, sapota, guava, pomegranate, bael, ber, amla, anona, fig, pineapple, jackfruit, avocado, mangosteen, litchi, carambola, durian, rambutan, bilimbi, loquat, rose apple breadfruit and passion fruit
2.	Training and pruning of grapes, mango, guava and citrus.
3.	Selection of site and planting system
4.	Pre-treatment of banana suckers, desuckering in banana, sex forms in papaya
5.	Use of plastics in fruit production
6.	Visit to commercial orchards and diagnosis of maladies
7.	Manure and fertilizer application including bio-fertilizer in fruit crops
8.	Preparation and application of growth regulators in banana, grapes and mango
9.	Seed production in papaya, latex extraction and preparation of crude papain
10.	Ripening of fruits, grading and packaging
11.	Production economics for tropical and sub-tropical fruits
12.	Mapping of arid and semi-arid zones of India
13.	Botanical description and identification of ber, fig, jamun, pomegranate, carissa, phalsa, wood apple, West Indian cherry, tamarind, aonla, bael and annona

Suggested Readings:

- H. P. Singh and M. M. Mustafa, 2009. Banana-new innovations. Westville Publishing House, New Delhi.
- M. S. Ladaniya, 2013. Citrus Fruits. Elsevier, India post ltd.
- Bose, T.K., Mitra, S.K. and Sanyal, D., 2002. Tropical and Sub-Tropical-Vol-I. Nayaudyog-Kolkata
- Rajput, CBS and Srihari babu, R., 1985. Citriculture. Kalyani Publishers, New Delhi.
- Chundawat, B.S., 1990. Arid fruit culture. Oxford and IBH, New Delhi.

- Chadha, K. L. (ICAR) 2002, 2001. Hand book of Horticulture. ICAR, New Delhi.
- Symmonds, 1996. Banana. II Edn. Longman, London.
- Radha, T. and Mathew, L., 2007. Fruit crops. New India Publishing Agency.
- W. S. Dhillon, 2013. Fruit Production in India. Narendra Publishing House, New Delhi
- T. K. Chattopadhyay, 1997. Text book on pomology. Kalyani Publishers, New Delhi.
- R. E. Litz, 2009. The Mango 2nd Edn. Cabi Publishing, Willingford, U.K.
- K. L. Chadda, 2009. Advanced in Horticulture. Malhotra Publishing House, New Delhi.
- S.P. Singh, 2004. Commercial fruits. Kalyani Publishers, New Delhi.
- F.S. Davies and L.G.Albrigo, 2001. Citrus, Cab International.

10. FSC – 216 (Temperate Fruit Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Classification of temperate fruits
2.	Apple: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
3.	Pear: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
4.	Peach: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
5.	Apricot: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
6.	Plum: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
7.	Cherry: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
8.	Persimmon: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed

	management, harvesting, post-harvest handling and storage
9.	Strawberry: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
10.	Kiwi: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
11.	Queens land nut (Mecademia nut) and almond: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
12.	Walnut and pecan nut: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
13.	Hazel nut and Chest nut: Detailed study of areas, production, productivity varieties, climate and soil requirements, propagation, planting density, cropping systems, after care training and pruning, self-incompatibility and pollinisers, use of growth regulators, nutrient and weed management, harvesting, post-harvest handling and storage
14.	Re-plant problem, rejuvenation
15.	Special production problems like pre-mature leaf fall, physiological disorders, important insect – pests and diseases and their control measures
16.	Special production problems like alternate bearing problem and their remedies

Topics in Practical:

S. No.	Topics
1.	Nursery management practices of apple, pear, peach, apricot, plum, cherry, persimmon, strawberry, kiwi, Queens land nut (Mecademia nut), almond, walnut, pecan nut, hazel nut and chest nut
2.	Description and identification of varieties of apple, pear, peach, apricot, plum, cherry, persimmon, strawberry, kiwi, Queens land nut (Mecademia nut), almond, walnut, pecan nut, hazel nut and chest nut
3.	Manuring and fertilization, planting systems, preparation and use of growth regulators, training and pruning in apple, pear, plum, peach
4.	Manuring and fertilization, planting systems, preparation and use of growth regulators, training and pruning in nut crops
5.	Visit to private orchards to diagnose maladies
6.	Working out economics for apple, pear, plum and peach

Suggested Readings:

- Chattopadhyay, T.K., 2009. A text book on Pomology-IV Devoted to Temperate fruits. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Banday F.A. and Sharma M.K.,2010.Advances in Temperate Fruit Production. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Kaushal Kumar Misra, 2014.Text book of Advanced Pomology. Biotech Books.4762-63, Ansari Road, Darya Ganj, New delhi-11002.
- Das B.C. and Das S.N .Cultivation of Minor Fruits. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Pal J.S. 2010. Fruit Growing .2010. Kalyani Publishers.B-1/292,Rajinder Nagar, Ludhiana-141008.
- Mitra S.K, Rathore D.S and Bose T .K., 1992. Temperate Fruit Crops. Horticulture and Allied Publishers, Calcutta.
- Chattopadhya, T.K. 2000. A Text Book on Pomology (Temperate Fruits) Vol. IV Kalyani Publishers, Hyderabad
- Chadha, T.R., 2001. Text Book of Temperate Fruits. Indian Council of Agricultural Research, New Delhi.
- David Jackson & N E Laone, 1999. Subtropical and Temperate Fruit Production. CABI, Publications.
- W. S. Dhillon, 2013. Fruit Production in India. Narendra Publishing House. New Delhi

- Chattopadhyay, T.K., 2009. A text book on Pomology-IV Devoted to Temperate fruits. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Banday F.A. and Sharma M.K.,2010.Advances in Temperate Fruit Production. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Kaushal Kumar Misra, 2014.Text book of Advanced Pomology. Biotech Books.4762-63, Ansari Road, Darya Ganj, New delhi-11002.
- Das B.C. and Das S.N .Cultivation of Minor Fruits. Kalyani Publishers.B-1/292, Rajinder Nagar, Ludhiana-141008.
- Pal J.S. 2010. Fruit Growing .2010. Kalyani Publishers.B-1/292,Rajinder Nagar, Ludhiana-141008.
- Mitra S.K, Rathore D.S and Bose T .K., 1992. Temperate Fruit Crops. Horticulture and Allied Publishers, Calcutta.

11. FSC – 227 (Dry land Horticulture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Definition, importance and limitation of dry land horticulture, present status and future scope
2.	Constraints encounter in dry lands
3.	Agro-climatic features in rain shadow areas, scarce water resources, high temperature, soil erosion, run-off losses etc
4.	Techniques and management of dry land horticulture. watershed development, soil and

	water conservation methods-terraces, contour bunds etc.
5.	Methods of control and impounding of run-off water-farm ponds, trenches, macro catch pits, etc.
6.	*In-situ* water harvesting methods, micro catchment, different types of tree basins etc.
7.	Methods of reducing evapotranspiration, use of shelter belts, mulches, antitranspirants, growth regulators, etc.
8.	Water use efficiency-need based, economic and conjunctive use of water, micro systems of irrigation etc.
9.	Selection of plants having drought resistance
10.	Special techniques, planting and after care-use of seedling races, root stocks, *in-situ* grafting, deep pitting/planting, canopy management etc.
11.	Characters and special adaptation of crops: ber, aonla, annona, jamun, wood apple, bael, pomegranate, carissa, date palm, phalsa, fig, west Indian cherry and tamarind

Topics in Practical:

S. No.	Topics
1.	Study of rainfall patterns
2.	Contour bunding/trenching, ,
3.	Micro catchments
4.	Soil erosion and its control
5.	Study of evapotranspiration, mulches and micro irrigation systems
6.	Special techniques of planting and aftercare in dry lands
7.	Study of morphological and anatomical features of drought tolerant fruit crops.

Suggested Readings:

- Chundawat, B.S. 1990. Arid Fruit Culture. Oxford and IBH, New Delhi.
- P.L. Taroj, B.B. Vashishtha, D.G. Dhandar. 2004. Advances in Arid Horticulture. Internal Book Distributing Co., Lucknow.
- T. Pradeep Kumar, B. Suma, Jyothi Bhaskar and K. N. Sathesan. 2008. Management of Horticultural Crops. New India Publishing Agency.

12. AGR – 212 (Weed Management in Horticultural Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Weeds: Introduction, harmful and beneficial effects of weeds.
2.	Classification of weeds.
3.	Propagation and dissemination of weeds.
4.	Weed biology and ecology.

5.	Crop weed association, crop weed competition and allelopathy.
6.	Concepts of weed prevention, control and eradication.
7.	Methods of weed control: mechanical, cultural, chemical and biological methods.
8.	Integrated weed management.
9.	Herbicides: advantages and limitation of herbicide usage in India.
10.	Herbicide classification, formulations, methods of application.
11.	Introduction to Adjuvants and their use in herbicides.
12.	Introduction to selectivity of herbicides.
13.	Compatibility of herbicides with other agro chemicals.
14.	Weed management in major field and horticultural crops.
15.	Shift of weed flora in cropping systems.
16.	Aquatic and problematic weeds and their control.

Topics in Practical:

S. No.	Topics
1.	Identification of weeds.
2.	Survey of weeds in crop fields and other habitats.
3.	Preparation of herbarium of weeds.
4.	Calculations on weed control efficiency and weed index.
5.	Herbicide label information
6.	Computation of herbicide doses.
7.	Study of herbicide application equipment and calibration.
8.	Demonstration of methods of herbicide application.
9.	Preparation of list of commonly available herbicides.
10.	Study of phytotoxicity symptoms of herbicides in different crops.
11.	Biology of nut sedge, bermuda grass, parthenium and celosia.
12.	Economics of weed control practices.
13.	Tours and visits of problem areas.

Suggested Readings:

- Crafts, A.S. and Robbins, W.W. 1973. Weed Control. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- Gupta, O.P. 1984. Scientific Weed Management. Today and Tomorrow Printers and Publishers, New Delhi.
- Gupta, O.P. 2015. Modern Weed Management. Agro Bios (India), Jodhpur.
- Naidu, V.S.G.R., Handbook of Weed Identification. Directorate of Weed Research, Jabalpur.
- Rajagopal, A., Aravindan, R. and Shanmugavelu, K.G., 2015. Weed Managementof Horticultural Crops. Agrobios (India), Jodhpur.

13. FSC – 318 (Orchard and Estate Management)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Orchard & estate management, importance, objectives, merits and demerits
2.	Clean cultivation, sod culture, Sod mulch, herbicides and inorganic and organic mulches
3.	Tropical, sub-tropical and temperate horticultural systems, competitive and complimentary effect of root and shoot systems
4.	Biological efficiency of cropping systems in horticulture, systems of irrigation
5.	Soil management in relation to nutrient and water uptake and their effect on soil environment, moisture, organisms and soil properties
6.	Factors influencing the fruitfulness and unfruitfulness
7.	Rejuvenation of old orchards, top working, frame working
8.	Integrated nutrient and pest management
9.	Utilization of resources constraints in existing systems
10.	Crop model and crop regulation in relation to cropping systems
11.	Climate aberrations and mitigation measures of Horticultural crops

Topics in Practical:

S. No.	Topics
1.	Layout of different systems of orchard and estate
2.	Soil management clean, inter, cover and mixed cropping, fillers
3.	Use of mulch materials, organic and inorganic
4.	Moisture conservation
5.	Weed control
6.	Layout of various irrigation systems

Suggested Readings:

- Kumar, 1990. Introduction to Horticulture crops. Rajyalakshmi Publications, Nagercoil, Tamilnadu.
- Palaniappan, S.P. and Sivaraman, K. 1996. Cropping systems in the Tropics. New age International (P) Ltd., Publishers, New Delhi.
- Shanmugavelu, K.G.1989. Production Technology of Fruit Crops. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- W.S. Dhillon and Bhatt. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi.
- B .C. Mazumdar. 2004. Principles and Methods of Orchard Establishment. Daya Publishing House, New Delhi.
- T. Pradeep Kumar, B. Suma, Jyothi Bhaskar and K. N. Satheson. 2008. Management of Horticultural Crops. New India Publishing Agency, New Delhi.

➢ B .C. Mazumdar. 2004. Orchard Irrigation and Soil Management Practices Daya Publishing Agency, New Delhi. Daya Publishing Agency, New Delhi.

14. GPB – 111 (Principles of Genetics and Cytogenetics)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Historical background of genetics
2.	Theories and hypothesis
3.	Physical basis of heredity
4.	Cell reproduction, mitosis, meiosis and its significance
5.	Gametogenesis and syngamy in plants
6.	Mendelian genetics–Mendel's principles of heredity
7.	Deviation from Mendelian inheritance,
8.	Pleiotropy, threshold characters, co-dominance, penetrance and expressivity
9.	Chromosome theory of inheritance,
10.	Gene interaction
11.	Modification of monohybrid and dihybrid rations
12.	Multiple alleles
13.	Quantitative inheritance linkage and crossing over, sex linked inheritance and characters
14.	Cytoplasmic inheritance and maternal effects
15.	Chemical basis of heredity,
16.	Structure of DNA and its replication
17.	Evidence to prove DNA and RNA – as genetic material
18.	Mutations and their classification
19.	Chromosomal aberrations, changes in chromosome structure and number.

Topics in Practical:

S. No.	Topics
1.	Study of fixatives and stains
2.	Squash and smear techniques
3.	Demonstrations of permanent slides and cell division, illustration in plant cells,
4.	Pollen fertility and viability
5.	determination of gametes
6.	Solving problems of monohybrid, dihybrid, and test cross ratios using chi-square test
7.	Gene interactions

8.	Estimation of linkages using three point test cross from F2 data and construction of linkage maps

Suggested Readings:

- Gardner E J, Simmons M J & Snustard D P. Principles of Genetics (VIII Edn). John Wiley & Sons, New York.
- Strickberger. Genetics. Macmillan Publishing Company, New York.
- Phundan Singh. Elements of Genetics. Kalyani publishers, New Delhi.
- Stent & Calendar. Molecular Genetics (II Ed.). CBS Publishers, New Delhi
- Singh B. D. Fundamentals of Genetics. Kalyani Publishers, New Delhi
- Srivastava & Tyagi. Selected Problems in Genetics (Vol.1-3). Anmol Publications Pvt. Ltd., New Delhi.
- Khanna V.K. Genetics–Numerical Problems. Kalyani Publishers, New Delhi.
- Farook& Khan. Genetics & Cytogenetics (I Ed.). Premier Publishing House, Hyderabad.
- Shukla. Cell Biology (2001). Dominant publishers, New Delhi.
- George Acquaah. Principles of Plant Genetics and Breeding. Blackwell.
- B.D. Singh. Fundamental of Genetics. Kalyani. India.
- Gupta, P.K. 1985.Cytology, genetics and cytogenetics. Rastogi Publication, India.

15. GPB – 122 (Principles of Plant Breeding)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Plant breeding as dynamic science
2.	Genetic basis of plant breeding (classical and quantitative)
3.	Genetic basis of plant breeding (molecular)
4.	Plant breeding in India (limitation ,achievement and goal setting for future)
5.	Reproduction (cross and self-pollination)
6.	Asexual reproduction (apomixes)
7.	Pollination mechanism
8.	Pollination control mechanism (incompatibility and sterility and implications of reproductive systems on population Structure)
9.	Genetic components of polygenic variation and breeding strategies
10.	Selection as a basis of crop breeding and marker assisted selection
11.	Hybridization and selection – goals of hybridization
12.	Selection of plants; population developed by hybridization – simple crosses, bulk crosses and complex crosses
13.	General and special breeding techniques

14.	Heterosis – concepts, estimation and its genetic basis.
15.	Calculation of average heterosis, heterobeltosis, GCA, SCA, inbreeding depression, heritability and genetic advance
16.	Emasculation, pollination techniques in important horticultural crops.
17.	Breeding for resistance of biotic and abiotic stresses
18.	Polyploidy breeding and mutation breeding

Topics in Practical:

S. No.	Topics
1.	Breeding objectives and techniques in important horticultural crops
2.	Floral biology – its measurement, emasculation, crossing and selfing techniques in major Horticulture and field crops
3.	Determination of mode of reproduction in crop plants
4.	Handling of breeding materials, segregating generations (pedigree, bulk and back cross methods)
5.	Field layout and maintenance of experimental records in self- and cross-pollinated crops.
6.	Demonstration of hybrid variation and production techniques
7.	Hardy Weinberg Law and calculation
8.	Male sterility and incompatibility studies in horticultural crops
9.	Calculation of inbreeding depression, average heterosis , heterobeltioses, GCA, SCA, GA and heritability

Suggested Readings:

- B D Singh. Fundamental of Plant breeding. Kalyani Publications India.
- B.D. Singh. Plant breeding : principles and methods. Kalyani Publishers, Ludhiana.
- V.L. Chopra. Plant breeding: Theory and Practice. Oxford & IBH Publishing CO. Pvt. Ltd. New Delhi.
- J.R. Sharma. Principles and practices of plant breeding. Tata McGraw Publishing Company Ltd., New Delhi.
- G. S. Chahal and S.S. Gosal.2002. Principles and Procedures of Plant Breeding. Narosa Publishing House, New Delhi.

16. GPB – 223 (Breeding of Fruit and Plantation Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	**Mango**: History, importance in fruit production, distribution, domestication and adaptation of commercially important fruits, variability for economic traits, breeding strategies, clonal selection, bud mutations, mutagenesis and its application in crop improvement – policy manipulations – *in vitro* breeding tools

17. PSMA – 222 (Plantation Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	History and development, scope and importance, area and production, export and import potential, role in national and state economy, uses, industrial importance, by products utilization
2.	Coconut: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, nutrition, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
3.	Arecanut: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, nutrition, role of growth regulators, soil management, liming practices, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
4.	Oil palm: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, nutrition, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing
5.	Palmyrah palm: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, nutrition, foliar feeding, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing
6.	Cacao: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
7.	Cashew nut: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micropropagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, top working, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
8.	Coffee: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, shade regulation, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, liming practices, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics

9.	Tea: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, shade regulation, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, liming practices, tipping practices, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
10.	Date palm: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management, nutrition, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics
11.	Rubber: Soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, weed and water management , nutrition, foliar feeding, role of growth regulators, soil management, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics

Topics in Practical:

S. No.	Topics
1.	Description and identification of coconut varieties
2.	Selection of Coconut and Arecanut mother palm and seed nut, planting of seed nuts in nursery
3.	Layout and planting of Coconut, Arecanut, Oil palm, Cashew nut, Cocoa gardens, manuring, irrigation; mulching, raising masonry nursery for palm, nursery management in cacao
4.	Description and identification of species and varieties in coffee, harvesting, grading, pulping, fermenting, washing, drying and packing of coffee, seed berry collection, seed extraction, treatment and sowing of coffee
5.	Epicotyl, softwood, grafting and top working in cashew, working out the economics and Project preparation for Coconut, Arecanut, Oil palm, Cashew nut, Cocoa, etc.
6.	Mother plant selection, preparation of cuttings and rooting of tea under specialized structure, training, centering, pruning, tipping and harvesting of tea

Suggested Readings:

- Kumar, N.J.B. M. Md. Abdul Khaddar, Ranga Swamy, P. and Irrulappan, I. 1997. Introduction to spices, Plantation crops and Aromatic plants. Oxford & IBH, New Delhi.
- Thampan, P.K. 1981.Hand Book of Coconut Palm. Oxford IBH, New Delhi.
- Nair, M.K., Bhaskar Rao, E.V.V., Nambiar, K.K.N. and Nambiar, M.C. 1979. Cashew, CPCRI, Kerala.
- Wood, GAR, 1975. Cacao. Longmen, London.
- Ranganadhan, V. 1979. Hand Book of Tea Cultivation. UPASI Tea Research Station, Cinchona.
- Thompson, P.K. 1980. Coconut. Oxford & IBH Publishing Co. Ltd., New Delhi.

Department – Floriculture and Landscape Architecture

18. FLA – 111 (Principles of Landscape Architecture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Historical importance of Indian gardens
2.	Gardens of ancient world
3.	Famous gardens of India and abroad
4.	Types of gardens- formal, informal, wild and free style
5.	Basic themes of garden- circular, rectangular and diagonal themes
6.	Use of Auto CAD and Archi CAD in designing gardens
7.	Factors affecting landscape design- initial approach, view, human choice, simplicity, topography etc.
8.	Principles of landscape gardening- axis, rhythm, balance, time and light, space, texture, form, mass effect, focal point, mobility, emphasis, unity, harmony etc
9.	Elements of landscape garden- tangible and intangible elements
10.	Bio- aesthetic planning- definition and objectives
11.	Planning and designing of home gardens, colonies, country planning and urban landscape
12.	Development of institutional gardens, avenue planting, beautifying schools, railway lines, railway stations, factories, bus stands, air ports, corporate buildings, dams, hydro electric stations, river banks, play grounds
13.	Gardens for places of religious importance- temples, churches, mosques, tombs etc
14.	Importance, features and establishment of English gardens, Japanese gardens, Mughal gardens, French gardens, Persian gardens, Italian gardens, Hindu- Buddhist gardens
15.	Xeriscaping- definition, principles and practice

Topics in Practical:

S. No.	Topics
1.	Study of garden tools and equipment
2.	Study of graphic language
3.	Use of drawing equipment, graphic symbols and notations in landscape designing
4.	Study and designing of different styles of gardens
5.	Study and designing of gardens based on different themes
6.	Designing gardens using AutoCAD/ ArchiCAD
7.	Designing gardens for homes, traffic islands, schools and colleges
8.	Designing gardens for public buildings and factories
9.	Designing gardens for railway stations and airports

10.	Designing gardens for temples and churches
11.	Designing gardens for play grounds and corporate buildings/ malls
12.	Designing and planting avenues for state and national highways
13.	Design and establishment of Japanese and English gardens
14.	Design and establishment of Mughal gardens
15.	Visit to public, institutional and botanical gardens

19. FLA – 324 (Breeding and Seed Production of Flower and Ornamental Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	History of improvements of ornamental plants, centre of origin of flower crops and ornamental crops
2.	Objectives and techniques in ornamental plant breeding
3.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants., Rose, Jasmine
4.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants. Chrysanthemum,
5.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Tuberose
6.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Gerbera, Gladiolus
7.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Dahlia, Heliconia, Lilium
8.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Gaillardia, Petunia, *Hibiscus*
9.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Bouganvillea, Zinnia, Cosmos
10.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants Dianthus, Snapdragon, Pansy, crossandra
11.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants marigold, , geranium, antirrhinium
12.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants china aster, orchids,
13.	Introduction, selection, hybridization, mutation and biotechnological technique for improvement of ornamental plants anthurium, carnation, hibiscus
14.	Breeding for disease resistance
15.	Development of promising cultivars of important ornamentals and flower crops
16.	Role of heterosis and its exploitation

17.	Production of F1 hybrids and utilization of male sterility
18.	Production of open pollinated seed
19.	Harvesting, processing and storage of seeds,
20.	Seed certification.

Topics in Practical:

S. No.	Topics
1.	Study of floral biology and pollination in important species and cultivars Rose, Jasmine, Chrysanthemum, Tuberose, Gerbera, Gladiolus, dahlia Heliconia, Lilium, Gaillardia, Petunia, Hibiscus, Bouganvillea, Zinnia, Cosmos, Dianthus, Snapdragon, Pansy, crossandra, marigold, , geranium, antirrhinium, china aster, orchids, anthurium, carnation, hibiscus
2.	Techniques of inducing polyploidy and mutation
3.	Production of pure and hybrid seeds
4.	Practice in seed production methods

Suggested Readings:

- B.P. Pal. The Rose in India.1966.Directorate of Knowledge management in Agriculture, Indian council of Agriculture Research-New Delhi.
- T.K. Bose, L.P. Yadav, P. Patil, P. Das and V.A. Partha Sarthy. 2003. Commercial flowers. Partha Sankar Basu, Nayaudyog, 206, Bidhan Sarani, Kolkata-700006.
- S.K. Bhattacharjee and L.C. De. 2003. Advanced Commercial Floriculture. Aavishkar Publishers, Distributors, Jaipur (Rajasthan) India.
- D.J. Callaway and M.B. Callaway. 2000. Breeding Ornamental Plants. Timber Press
- A.J.Salaria and B.S.Salaria . 2011.A_2 Z Horticulture at a glance-III .INTLLECTS –Nurture to excel Jammu

20. FLA – 212 (Commercial Floriculture)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Scope and importance of commercial floriculture in India
2.	Production technology of rose
3.	Production technology of marigold
4.	Production technology of chrysanthemum
5.	Production technology of orchids
6.	Production technology of carnation
7.	Production technology of gladiolus
8.	Production technology of jasmine

9.	Production technology of crossandra
10.	Production technology of anthurium
11.	Production technology of dahlia
12.	Production technology of tuberose
13.	Production technology of bird of paradise
14.	Production technology of China Aster
15.	Production technology of gerbera
16.	Production techniques of foliage and filler materials
17.	Growing of flowers under protected environments- glass house, plastic house etc.
18.	Post-harvest technology of cut flowers in respect of commercial flower crops
19.	Flower dehydration techniques
20.	Production techniques for bulbous ornamentals

Topics in Practical:

S. No.	Topics
1.	Identification of commercially important floricultural crops
2.	Propagation practices in chrysanthemum
3.	Sowing of seeds and raising of seedlings in annuals
4.	Propagation by cutting, layering, budding and grafting
5.	Training and pruning of roses
6.	Use of chemicals and other compounds for prolonging the vase life of cut flowers
7.	Drying and preservation of flowers
8.	Flower arrangement practices

Suggested Readings:

- Bhattacharjee SK. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

21. FLA – 223 (Ornamental Horticulture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	History, definition and scope of ornamental horticulture
2.	Floriculture industry
3.	Importance, area and production of floricultural crops
4.	Industrial importance of ornamental plants and flowers
5.	Importance and classification of ornamental plants
6.	General cultivation aspects of flowering annuals
7.	General cultivation aspects of herbaceous perennials
8.	General cultivation aspects of grasses, reeds and bamboos
9.	General cultivation aspects of bulbous ornamentals
10.	General cultivation aspects of shrubs
11.	General cultivation aspects of climbers
12.	General cultivation aspects of trees
13.	General cultivation aspects of indoor plants
14.	General cultivation aspects of palms and cycads
15.	General cultivation aspects of ferns and selaginella
16.	General cultivation aspects of cacti and other succulents
17.	Importance, design and establishment of garden features/ components- hedge, edge, borders, flower beds, bridges, paths, drives, fences
18.	Importance, design and establishment of garden features/ components- garden walls, gates, carpet bed, arbour, patio, decking, retaining walls
19.	Importance, design and establishment of garden features/ components- shade garden, sunken garden, roof garden, terrace garden, pebble garden
20.	Importance, design and establishment of garden features/ components- rockery, pools, water falls, fountains, bog garden, avenue planting and children garden
21.	Lawn- types, establishment and maintenance
22.	Importance of garden adornments- floral clock, bird bath, statues, sculpture, lanterns, water basins, garden benches etc.
23.	Importance of flower arrangement, Ikebana- techniques, types, suitable flowers and cut foliage
24.	Vertical garden, bottle garden, terrarium
25.	Art of making bonsai, culture of bonsai and maintenance

Topics in Practical:

S. No.	Topics

1.	Identification and description of flowering annuals
2.	Identification and description of biennials
3.	Identification and description of herbaceous perennials
4.	Identification and description of climbers
5.	Identification and description of shrubs
6.	Identification and description of indoor plants
7.	Identification and description of ferns and selaginella
8.	Identification and description of palms and cycads
9.	Identification and description of cacti and other succulents
10.	Planning, designing and establishment of garden features- lawn
11.	Planning, designing and establishment of garden features- hedge and edge
12.	Planning, designing and establishment of garden features- rockery
13.	Planning, designing and establishment of garden features- water garden
14.	Planning, designing and establishment of garden features- carpet bedding
15.	Planning, designing and establishment of garden features- shade garden
16.	Planning, designing and establishment of garden features- roof garden
17.	Study and creation of terrariums
18.	Study and creation of vertical gardens
19.	Study and practice of different types of flower arrangements
20.	Preparation of floral bouquets
21.	Preparation of floral rangoli
22.	Preparation of veni
23.	Study of bonsai techniques
24.	Bonsai practice and training
25.	Visit to nurseries and floriculture units

Suggested Readings:

- Adriance GW and Brison FR. 2000. Propagation of Horticultural Plants. Biotech Books, New Delhi, India.
- Bose TK, Mitra SK and Sadhu M K. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash, Kolkata, India.
- Rajan S and Baby LM. 2007. Propagation of Horticultural Crops. New India Publ. Agency, New Delhi, India. pp. 251.

22. PSMA – 313 (Medicinal and Aromatic crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics

1.	History, scope, opportunities and constraints in the cultivation and maintenance of medicinal and aromatic plants in India.
2.	Importance, origin, distribution, area, production, climatic and soil requirements, propagation and nursery techniques, planting and after care, cultural practices, training and pruning, nutritional and water requirements viz. aswagandha, safed musli, tulsi, kalmegh, lemon grass, citronella, opium, asalio, isabgol, satawar, mentha spp
3.	Plant protection, harvesting and processing of under mentioned important medicinal and aromatic plants.viz. asgandh, safed musli, tulsi, kalmegh, lemon grass, citronella, opium, asalio, isabgol, satawar, mentha spp.
4.	Study of chemical composition of a few important medicinal and aromatic plants, extraction, use and economics of drugs and essential oils in medicinal and aromatic plants.
5.	Therapeutic and pharmaceutical uses of important species.
6.	Storage techniques of essential oils. Medicinal Plants: Withania, periwinkle, Rauvolfia, Dioscorea, Isabgol, opium poppy, Ammi majus, Belladonna, Cinchona, Pyrethrum and other medicinal crops relevant to local conditions.
7.	Aromatic Plants: Citronella grass, khus grass, flag (baje), lavender, geranium, patchouli, bursera, mentha, musk, occimum and other species relevant to the local conditions. Marketing.

Topics in Practical:

S. No.	Topics
1.	Collection and conservation of medicinal and aromatic plants from their natural habitat and their study morphological description,
2.	Nursery techniques of medicinal and aromatic crops.
3.	Harvesting of medicinal and aromatic crops.
4.	Curing and processing techniques of medicinal and aromatic crops.
5.	Extraction of essential oils.

Suggested Readings:

- Chadha, K.L. ICAR, 2001. Hand Book of Horticulture. Directorate of Information and Publications of Agriculture, Pusa, New Delhi.
- Azhar Ali Farooqui and Sreeramu, B.S. 2001. Cultivation of medicinal and aromatic plants.
- United Press Limited.
- Atal, E.K. and Kapur, B. 1982. Cultivation and Utilization of Medicinal and Aromatic plants.
- CSIR, New Delhi.
- Kumar, N. J.B.M. Md. Abdul Khaddar, Ranga Swamy, P. and Irulappan, I. 1997. Introduction to Spices, Plantation Crops Medicinal and Aromatic Plants.Oxford & IBH, New Delhi.
- Jain, S.K. 1968. Medicinal Plants .National Book Trust New Delhi. Oxford & IBH, New Delhi.
- Dastur, J.F. 1982. Medicinal plants of India Pakistan Taraprevala soms and co-private Ltd, Bombay

Department – Natural Resource Management

23. SAC – 111 (Fundamentals of Soil Science)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Composition of earth's crust, soil as a natural body – major components. Eluviations and alleviations formation of various soils
2.	Physical parameters; texture – definition, methods of textural analysis, stock's law, assumption, limitations, textural classes, use of textural triangle
3.	Absolute specific gravity/particle density, definition, apparent specific gravity/bulk density – factors influencing, bulk density. Relation between BD (bulk density), PD – practical problems. Pore space – definition and factors affecting capillary and non-capillary porosity
4.	Soil colour – definition, its significance, colour variable, value hue and chroma. Munsellcolour chart, factors influencing the color of soil
5.	Parent material, soil moisture, organic matter, soil structure, definition, classification, factors influencing genesis of soil structure.
6.	Soil consistency, plasticity, Atterberg's constants Soil air, air capacity, composition, factors influencing, amount of air space, soil air renewal
7.	Soil temperature, sources and distribution of heat, factors influencing, measurement
8.	Chemical properties, soil colloids, organic, humus, inorganic, secondary silicate, clay, hydrous oxides. Ion exchange, cation-anion and importance
9.	Soil water its forms, hygroscopic, capillary and gravitational, soil moisture constants, hygroscopic coefficient, wilting point, field capacity, moisture equivalent, maximum water holding capacity, energy concepts, PF scale
10.	Measurement of soil water, gravimetric – electric and densitometer methods – pressure plate and pressure membrane apparatus – Neutron probe – soil water movement – classification
11.	Aerial photography – satellite of soil features – their interpretation. soil orders; land capability classification
12.	Soil of different eco-systems and their properties. Rock & Minerals classification, Pathogenic process
13.	Objectives of soil science research institute in India (NBSS&LUP, ISSS, LTFE & NSSTL)
14.	Management of Soil Crusting, Soil Compaction and Soil Compression
15.	Soil Biology benefits and harmful effects.
16.	Methods and objective of soil survey, Remote sensing application in soil and plant Studies, Soil degradation

Topics in Practical:

S. No.	Topics

1.	Collection and preparation of soil samples
2.	Estimation of moisture, EC, pH and bulk density.
3.	Textural analysis of soil by Robinson's pipette method
4.	Description of soil profile in the field.
5.	Quantification of minerals and their abundance.
6.	Determination of Soil colour using Munsell Chart.
7.	Estimation of water holding capacity and hydraulic conductivity of soils.
8.	Estimation of Infiltration rate using double ring infiltrometer method.
9.	Estimation of soil moisture using gypsum block and neutron probe method
10.	Soil compaction measurement with Spectrometer.
11.	Determination of pore space of soil.
12.	Determination of filed capacity and permanent wilting point of soil.
13.	Determination of soil water potential characteristic curves by densitometer and pressure plate apparatus.
14.	Aggregate size distribution analysis of soil.
15.	Air capacity of soil by field method.

Suggested Readings:

- Brady Nyle C and Ray R Well, 2014. Nature and properties of soils. Pearson Education Inc., New Delhi.
- Indian Society of Soil Science, 2002. Fundamentals of Soil Science. IARI, New Delhi.
- Sehgal J. A., 2005. Textbook of Pedology Concepts and Applications. Kalyani Publishers, New Delhi.
- Dilip Kumar Das, 2015. Introductory Soil Science. Kalyani Publishers, Ludhiana.
- Biswas, T.D. and Mukharjee, S.K., 2015. Text Book of Soil science. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi.
- Brady, N.C., 1995. The Nature and properties of Soils. Macmillan Publishing Co, New York.
- Ghildyal, B.P. and Tripathi, R.P., 1987. Soil Physics. Acad. Press. New York.
- Kolay, A.K., 1983. Basic concepts of Soil Science. Wiley Eastern Ltd., New Delhi
- Brady, N. C. and Weil, R. R., 2010. Elements of the Nature and Properties of Soils (3rd Edition), Pearson Education, New Delhi.
- Foth, H.D., 1991. Fundamentals of Soil Science (8th Edition), John Wiley & Sons, New Delhi.
- Das, D .K., 2011. Introductory Soil Science (3rd Edition), Kalyani publisher, Ludhiana (India).
- Khan, T. O. 2013 Forest Soils: Properties and Management. Springer International Publishing, Switzerland
- Pritchett and Fisher RF, 1987. Properties and Management of Forest Soils. John Wiley, New York.
- Gupta, P.K. 2009. Soil, Plant, Water and Fertilizer Analysis (2nd Edition), AGROBIOS, Jodhpur (India).
- Jaiswal, P.C. 2006. Soil, Plant and Water Analysis (2nd Edition), Kalyani Publishers, Ludhiana.

24. SAC – 122 (Soil Fertility and Nutrient Management)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Plant nutrients - classification and sources
2.	Essential and beneficial elements, criteria of essentiality
3.	Forms of nutrients in soil, mechanisms of nutrient transport to plants
4.	factors affecting availability of major, secondary and micro nutrients to plants
5.	Measures to overcome deficiencies and toxicities
6.	Soil fertility- different approaches for soil fertility evaluation
7.	Soil testing for available nutrients; Critical levels of different nutrients in soil
8.	Plant analysis- total and rapid tissue tests- critical levels of nutrients in plants
9.	DRIS method; Deficiency symptoms-indicator plants
10.	Biological method of soil fertility evaluation
11.	Soil test-based fertilizer recommendations to crops.
12.	Factors influencing nutrient use efficiency (NUE) in respect of N, P, K, S, Fe and Zn fertilizers
13.	Source, method and scheduling of nutrients for different soils and crops grown under rainfed and irrigated conditions.
14.	Integrated plant nutrient supply system and its management.

Topics in Practical:

S. No.	Topics
1.	Analytical Instruments- principles, calibration and applications
2.	Estimation of available nitrogen in soil
3.	Available phosphorous in soil
4.	Available potassium in soil
5.	Available sulphur in soil
6.	Estimation of exchangeable calcium and magnesium in soil
7.	Estimation of available micronutrients in soils
8.	Preparation of plant samples for analysis
9.	Estimation of nitrogen in plant
10.	Phosphorus and potassium in plants

Suggested Readings:

- Yawalkar K S, Agarwal JP and Bokde S, 1992. Manures and Fertilizers. Agri. Horticultural Publishing House, Nagpur.
- Tandon HLS, 1994. Fertilizers Guide. Fertilizers Development Consultation Organization, New

Fertilizers Technology. The Fertilizers Association of India, New Delhi

25. SAC – 223 (Soil, Water and Plant Analysis)

Credit Hours: 2(1+1)

Topics in Theory:

S. No.	Topics
1.	Methods of soil and plant sampling and processing for analysis.
2.	Characterization of hydraulic mobility – diffusion and mass flow.
3.	Methods of estimation of oxygen diffusion rate and redox potential.
4.	Soil micro-organisms and their importance.
5.	Saline, alkali, acid, waterlogged and sandy soils, their appraisal and management.
6.	Chemical and mineral composition of horticultural crops.
7.	Leaf analysis standards, index tissue, interpretation of leaf analysis values
8.	Quality of irrigation water different quality parameters.
9.	Management of poor quality irrigation water in crop management.
10.	Use of radio tracer techniques in soil fertility evaluation and plant nutrient studies.
11.	Rapid tissue tests for plant.
12.	Soil and Water pollution.

Topics in Practical:

S. No.	Topics
1.	Introduction to analytical chemistry
2.	Collection and preparation of soil, water and plant samples for analysis.
3.	Determination of pH, electrical conductivity
4.	Sodium adsorption ratio and exchangeable sodium percentage of soils.
5.	Estimation of available macro and micronutrient elements in soils and their contents in plants.
6.	Irrigation water quality analysis.
7.	Determination of pH and EC in irrigation water samples
8.	Determination of Carbonates and bicarbonates in soil and irrigation water
9.	Determination of Calcium and Magnesium in soil and irrigation water.
10.	Determination of N, P, K, Ca, Mg, S and micronutrients in plant samples.
11.	Determination of Sodium, Potassium, Chlorine and Boron in irrigation water.

Suggested Readings:

- H.L.S. Tandon. 2013, Methods of analysis of soil, plant, water and fertilizers. FDCO, New Delhi.
- Yawalkar,K.S.Agarwal,J.P.andBokde,S.,1977. ManuresandFertilizers. Agri-Horticultural Publish

681 ing House,Nagpur.

- Sehgal J. A., 2005. Textbook of Pedology Concepts and Applications. Kalyani Publishers, New Delhi.
- Jaiswal, P.C., 2006. Soil, Plant and Water Analysis (2nd Edition), Kalyani Publishers, Ludhiana.
- Jackson M. L, 1967. Soil Chemical Analysis, Oxford and IBH Publishing Co., New Delhi.
- Richards L A, 1968. Diagnosis and Improvement of Saline and Alkaline Soils. Oxford and IBH publishing Co. New Delhi(USDA Hand Book No. 60)
- Chopra S.C. and Kanwar, J. S 1976. Analytical Agricultural Chemistry, Kalyani Publishers, Ludhiana.
- C. S. Piper. 2014, Soil and plant analysis, Scientific publishers India.
- Mushtaq A. Wan., 2014, Soil, plant and water analysis manual. Agrotech publishing company, Udaipur.
- P. K. Gupta., 2013, Soil, plant, water and fertilizer analysis. Agrobios, India.
- M. V. Durai., 2014, Hand book of Soil, plant, water, fertilizers and manure analysis. New India Publishing Agency.

26. AMT – 311 (Agro-meteorology and Climate Change)

Credit Hours: 2(1+1)

Topics in Theory:

S. No.	Topics
1.	Agricultural Meteorology- Introduction, definition of meteorology, scope and practical utility of Agricultural meteorology.
2.	Composition and structure of atmosphere and definition of weather and climate, aspects involved in weather and climate, atmospheric temperature, soil temperature, solar radiation, atmospheric pressure, atmospheric humidity, evaporation and transpiration, monsoons, rainfall, clouds, drought, weather disasters and their management atmospheric pollution and role of meteorology.
3.	Basics of weather forecasting.
4.	Climate change-causes.
5.	Global warming-causes and remote sensing.
6.	Effect of climate change on horticulture Past and future changes in greenhouse gases within the atmosphere.
7.	Sources and sinks for greenhouse gases.
8.	Atmospheric chemistry.
9.	Plants sense and respond to changes in CO_2 concentration.
10.	Measurement of short-term effects and mechanisms underlying the observed responses in C3 and C4 species.
11.	Plant development affected by growth in elevated CO_2.
12.	Physiology of rising CO_2 on nitrogen use and soil fertility, its implication for production. Methodology for studying effect of CO_2.

13.	Change in secondary metabolites and pest disease reaction of plants.
14.	The mechanisms of ozone and UV damage and tolerance in plants. Increased temperature and plants in tropical/sub-tropical climates- effect on growing season, timing of flowering, duration of fruit development and impacts on crop yields and potential species ranges, interaction of temperature with other abiotic/biotic stress.
15.	Mitigation strategies and prospects for genetic manipulation of crops to maximize production in the future atmosphere.
16.	Modifying Rubisco, acclimation, metabolism of oxidizing radicals, and sink capacity as potential strategies.

Topics in Practical:

S. No.	Topics
1.	Site selection for Agromet observatory.
2.	Measurement of temperature.
3.	Measurement of rainfall.
4.	Measurement of evaporation (atmospheric/soil).
5.	Measurement of atmospheric pressure.
6.	Measurement of sunshine duration and solar radiation.
7.	Measurement of wind direction and speed and relative humidity.
8.	Study of weather forecasting and synoptic charts.
9.	Visit to Meteorological observatory, Visit to IMD meteorological observatory-Lay out plan of standard meteorological observatory.
10.	Recording of air and soil temperature.
11.	Measurement of radiation and components.
12.	Measurement of rainfall-different types of rain gauges.
13.	Measurement of wind speed and direction and atmospheric humidity.
14.	Recording of evaporation.
15.	Synoptic charts and weather reports, symbols, *etc*.

Suggested Readings:

- A.K. Srivastava and P. K. Tyagi, 2011. Practical Agricultural Meteorology. New Delhi Publishing Agency, New Delhi.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- D.Lenka, 2006. Climate, Weather and Crops in India. Kalyani Publishers, New Delhi.
- G. S. L. H. V. Prasad Rao, 2008. Agricultural Meteorology. Prentice Hall of India Pvt. Ltd., New Delhi.
- H.S.Mavi and Graeme J. Tupper, 2005. Agrometeorology – Principles and applications of climate studies in agriculture. International Book Publishing Co., Lucknow.
- H.S.Mavi, 1994. Introduction to Agrometeorology. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

- H.V.Nanjappa and B.K.Ramachandrappa, 2007. Manual on Practical Agricultural Meteorology. Agrobios India. Jodhpur.
- S.R.Reddy, 1999. Principles of Agronomy. Kalyani Publishers, New Delhi.
- T.Yellamanda Reddy and G.H.Sankara Reddi, 2010. Principles of Agronomy. Kalyani Publishers, New Delhi.
- Pattersen, S.1958. Introductionto Meteorology. Mc. Graw Hill Book Co. Inc., New York
- Tailor, J.T.1967. AgriculturalClimatology. Pergman Press Ltd., Headington Hill Hall, Oxford, England
- Trewarthe,T.G.1968. An Introduction to Climate. Mc Graw Hill Book Co. Inc., New York.
- Mavi,H.S.1985. Introduction to Agrometeorology. Oxford & IBH Publishing Co., New Delhi.

27. EVS – 122 (Environmental Studies and Disaster Management)#

Credit Hours: 3(2+1)

Topics in Theory:

S. No.	Topics
1.	Multidisciplinary nature of environmental studies Definition, scope and importance.
2.	Natural Resources: Renewable and non-renewable resources. Natural resources and associated problems.
3.	a)Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
4.	b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
5.	c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
6.	d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
7.	e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.
8.	f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
9.	Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.
10.	Ecosystems, Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers.
11.	Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids.
12.	Introduction, types, characteristic features, structure and function of the following ecosystem:- a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem d. Aquatic-ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).
13.	Biodiversity and its conservation:-Introduction, definition, genetic, species & ecosystem

	diversity and biogeographical classification of India.
14.	Value of biodiversity - consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, National and local levels, India as a mega-diversity nation.
15.	Hot-spots of biodiversity. Threats to biodiversity - habitat loss, poaching of wildlife, man-wildlife Conflicts Endangered and endemic species of India.
16.	Conservation of biodiversity: In-situ and Exsitu
17.	Environmental Pollution: definition, cause, effects and control measures of - Air, Water, Soil, Marine, Noise and Thermal pollution and Nuclear hazards.
18.	Solid Waste Management: causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution.
19.	Social Issues and the Environment: From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain, water harvesting, watershed management, Environmental ethics: Issues and possible solutions.
20.	Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust dies.
21.	Wasteland reclamation, consumerism and waste products.
22.	Environment Protection Act, Air, Water, Wildlife and Forest Conservation acts, Issues involved in enforcement of environmental legislation and Public awareness.
23.	Human Population and the Environment: population growth, variation among nations, population explosion.
24.	Family Welfare Programme. Environment and human health: Human Rights, Value Education, HIV/AIDS. Women and Child Welfare.
25.	Role of Information Technology in Environment and human health.
26.	Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves.
27.	Climatic change: global warming, Sea level rise, ozone depletion.
28.	Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire.
29.	Air pollution, water pollution, deforestation, industrial waste water Pollution, road accidents, rail accidents, air accidents, sea accidents.
30.	Disaster Management-Effect to migrate natural disaster at national and global levels. International strategy for disaster reduction.
31.	Concept of disaster management, national disaster management framework; financial arrangements.
32.	Role of NGOs, community –based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response; Police and other organizations.

Topics in Practical:

S. No.	Topics
1.	Visit to a local polluted site-Urban
2.	Visit to a local polluted site- Rural
3.	Visit to a local polluted site- Industrial
4.	Visit to a local polluted site- Agricultural
5.	Study of common plants
6.	Study of common insects
7.	Study of common birds
8.	Study of simple ecosystems-pond, river, hillslopes etc.
9.	Visit to local areas - river/forest/ grassland/catchment etc. to document components of ecosystem.
10.	Visit to industries to study pollution abatement techniques and case studies
11.	Solid waste management
12.	Human population and the Environment

Suggested Readings:

- Nandini, N. Suneetha and Sucharitha Tandon. Environmental Studies.
- Aswathanarayana, U. 1999. Soil resources and the environment. Oxford and IBH publishing Co., New Delhi. P. 173-195.
- D. D. Misra. Fundamental Concepts in Environmental Studies.680 Rep
- Diwan, P. and P. Diwan. 1998. Environmental Management Law and Administration. Variety Books International, New Delhi.
- Krishnamurthy. An Advanced Textbook on Biodiversity.
- S. Deshwal A. Deshwal. A Basic Course in Environmental Science.
- Erach Bharucha 2005.Textbook of environmental studies for under graduate courses.UGC,University press, Hyderabad.
- Manohara Chary and Jayaram Reddy 2004.Principles of Environmental studies BB publishers,Hyderabad.
- William, P. Cunning Ham and Mary Ann. Inquiry and applications Cunningham 2005.
- Principles of Environmental science. Tata MCG raw-hill publishing company limited, NewDelhi.
- Gupta, P.K. 2004 Methods in environmental analysis-water, soil and Air. Agro Bios (India).Jodhpur.
- Spencer R. Weart. The discovery of global warming.
- Daniel B. Botkin, Edward A. Keller. Environmental Science.
- Richard T. Wright and Bernard J. Nebel Environmental science: toward a sustainable agriculture.
- Linfield C.Brown. Pollution prevention and control.

28. EVS – 313 (Introductory Agro-forestry)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Agroforestry – definition, objectives and potential. Distinction between agroforestry and social forestry.
2.	Status of Indian forests and role in Indian farming systems.
3.	Agroforestry system, subsystem and practice: Agri-silviculture, silvipastoral, horti-silviculture, horti-silvipastoral.
4.	Shifting cultivation, taungya, home gardens, alley cropping, intercropping. Wind breaks, shelterbelts and energy plantations.
5.	Planning for agroforestry – constraints, diagnosis and design methodology.
6.	Selection of tree crop species for agro-forestry. Agroforestry projects – national, overseas.
7.	MPTS and their management practices.
8.	Economics, cultivation, nursery and planting of *Acacia catechu.*
9.	Economics, cultivation, nursery and planting of *Dalbergiasissoo.*
10.	Economics, cultivation, nursery and planting of Tectona & Populus.
11.	Economics, cultivation, nursery and planting of Morus & Grewia.
12.	Economics, cultivation, nursery and planting of Eucalyptus & Quercus spp.
13.	Economics, cultivation, nursery and planting of bamboo.
14.	Economics, cultivation, nursery and planting of tamarind & neem.

Topics in Practical:

S. No.	Topics
1.	Identification and seeds and seedlings of multipurpose tree species.
2.	Nursery practices for poplar, Grewia Morus alba Acacia catechu and *Dalbergiasissoo*, robinia and leucaena.
3.	Visit to agro-forestry fields to study the compatibility of MPTS with agricultural crops, silvipastoral fields, alley cropping, horti-silviculture, agro-silvipasture, fuel and fodder blocks.
4.	Visit to social forestry plantations – railway line plantations.
5.	Visit to canal plantations.
6.	Visit to industrial plantations.
7.	Visit to shelterbelts.
8.	Rapid assessment of farmers needs for green manure, fodder, fuel wood in selected villages.
9.	Economics and marketing of products raised in agroforestry systems.

Suggested Readings:

- K. Patra, 2013. Agroforestry – Principles and Practices. New India publishing agency.
- P. Dwivedi, 1992. Agroforestry – Principles and Practices. Oxford and IBH Publishing company.
- Dadhwal et al., 2014. Practical Manual on Agroforestry. Jaya publishing house, Delhi.
- L.K. Jha, 2015. Advances in Agroforestry. APH Publishing corporation, New Delhi.
- Linford, Jenny, 2007. A Concise Guide to Trees. Parragon books service limited, Parragon.
- Negi, S.S., 2007. Agroforestry Hand book. International book distributer, New Delhi.
- P.S. Pathak and Ram Newaj, 2010. Agroforestry – Potentials and Opportunities. Agrobios, Jodhpur
- Pankaj Panwar & Sunil Puri, 2007. Agroforestry: Systems & Practices. New India publishing agency, New Delhi.
- Ramesh Umrani and C.K. Jain, 2010. Agroforestry – Systems & Practices. ABD Publishers, New Delhi.
- Ramachandran Nair, P.K. 1993. An Introductionto Agroforestry. First reprint in India–2008.Springer International Edition
- Tejawani, K.G. 1994. Agro forestry in India. Oxford & IBH, Publishing Co. Pvt. Ltd., New Delhi
- Luna, R.K. 1989. Plantation forestry in India. International Book Distributors, Dehradun.
- Leda Satish. 2006. Biodiesel and Jatropha Plantations. AGROBIOS, Jodhpur.
- Chaturvedi, A.N. and Khanna, L.S. 1982. Forest Menstruation. Reprinted in 2006. International Book Distributors, Dehradun
- Negi,S.S.2006. Forest Tree Seed. Prashant Gahlotat Valley printers and publishers, Dehradun.
- Chundawat and S K Gautam.1996. A text book of Agroforestry. Oxford and IBH Publishing company Pvt. Ltd.

29. AEG – 211 (Farm Power and Machinery)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Basic concepts of various forms of energy, unit and dimensions of force energy and power, calculations with realistic examples.
2.	Farm Power in India - Human, Animal, Mechanical and Electrical Energy Sources And Their Use In Agriculture
3.	Two Stroke and Four Stroke Engines, Working Principles, Applications - Types, Power and Efficiency
4.	Different Systems of IC Engine – Cooling, Lubricating, Fuel Injection Systems
5.	Tractors, Power Tillers and Their Types and Uses.
6.	Tillage - Objectives and Types, Furrow Terminology and Methods of Ploughing, Field Capacity and Field Efficiency
7.	Primary Tillage - Objectives, Mould Board Plough , Disc Plough, Chisel Plough, Sub-

	soiler , Components and Functions, Types, Advantages and Disadvantages
8.	Sowing Methods - Seed Drills, Seed Cum Fertilizer Drills - Components and Functions
9.	Implements For Intercultural Operations – Hoes, Long Handled Weeders, Cultivators, And Rotary Tillers
10.	Sprayers And Their Functions, Classification, Manually Operated Sprayers, Power Sprayers - Dusters, Types and Uses Sprayers
11.	Tools For Horticultural Crops – Propagation Tools, Planters and Harvesting Tools And Machinery
12.	Equipment For Land Development and Soil Conservation - Dozers, Levellers, Chisel Plough, Sub Soil Plough, Blade Harrow, Bund Former Land Levelling
13.	Cost Of Operation of Farm Machinery – Problem Solving
14.	Tractor And Implement Selection for Different Agricultural Operations
15.	Crop Harvesting Equipments: Potato Diggers, Fruit Pluckers, Tapioca Puller and Hoists.

Topics in Practical:

S. No.	Topics
1.	Calculation on force, power and energy
2.	IC engines – showing the components of dismantled engines and discussion about their functioning.
3.	Draw the neat sketch of engine components and discuss about them.
4.	Showing the components of dismantled motors and discuss about their parts.
5.	Draw the neat sketch of components of Induction motor and explain their importance.
6.	Showing different primary and secondary tillage implements and discussion about their parts, roles in operation.
7.	Adjustment of Suctions in Mould Board Plough
8.	Adjustment of Disc & Tilt Angle in Disc Plough
9.	Showing different Secondary tillage implements and discussion about their parts, roles in operation.
10.	Adjustment of hitching point and its operation
11.	Showing different types of Spraying equipments and their parts, calibration
12.	Draw the neat sketch of Knapsack sprayer and explain about its working
13.	Showing different types of Plant protection equipment and discussion about their parts, functioning etc.

Suggested Readings:

- T. P. Ojha and A.M. Michael. 2005. Principles of Agricultural Engineering (Volume - 1), Jain Brothers.
- Manoj Kumar Ghoshal and Dhirendra Kumar Das. 2008. Farm Power, Kalyani Publishers.
- Surendra Singh. 2007. Farm Machinery Principles and Applications. ICAR Publications.

- Roth/Field. 1992. Introduction to Agricultural Engineering - Problem Solving Approaches, 2nd. Edition. CBS publishers & distributors Pvt. Ltd.
- Surendra Singh & Verma. 2009. Farm Machinery Maintenance & Management. ICAR Publication.
- M.M. Pandey & Others. 2012. Handbook of Agricultural Engineering. ICAR publication
- Jagadishwar Sahay.1992. Elements of Agricultural Engineering. Agro Book Agency,Patna.
- Michal AM and Ojha TP.1993.VolI. Principles of Agricultural Engineering. Jain Brothers,New Delhi.
- Kepner R A Roy Bainer and Barger BL.1978. Principles of Farm Machinery. CBS Publisher and Distributors, Delhi.
- Jain S C. 2003. Farm Machinery-An approach. Standard Publishers and Distributors, New Delhi.
- Nakra, C.P.1986. Farm Machinery and Equipment. Dhanpat Rai and Sons, New Delhi.
- Klenin, N.I.Popov, I.F.and Sakun,V.A.1985. Agricultural Machines. Amerind publishing Co. Pvt. Ltd., New Delhi.

30. AGR – 122 (Water Management in Horticultural Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance of water.
2.	Water resources in India.
3.	Area of different crops under irrigation.
4.	Function of water for plant growth.
5.	Effect of moisture stress on crop growth.
6.	Available and unavailable soil moisture, distribution of soil moisture
7.	Water budgeting, rooting characteristics – moisture extraction pattern.
8.	Water requirement of horticultural crops, lysimeter studies.
9.	Plant water potential climatological approach.
10.	Use of pan evaporimeter.
11.	Factor for crop growth stages, Critical stages of crop growth for irrigation.
12.	Irrigation scheduling – different approaches.
13.	Methods of irrigation – surface and sub-surface pressurized methods viz., sprinkler and drip irrigation, their suitability, merits and limitations, fertigation.
14.	Economic use of irrigation water, water management problem,
15.	Soils quality of irrigation water, irrigation management practices for different soils and crops.
16.	Layout of different irrigation systems, drip, sprinkler, layout of underground pipeline system.

Topics in Practical:

S. No.	Topics
1.	Measurements of irrigation water by using water measuring devices.
2.	Use of common formula in irrigation practices.
3.	Practicing of land levelling and land shaping implements.
4.	Layout for different methods of irrigation.
5.	Estimation of soil moisture contents and soil moisture by using different methods and instruments.
6.	Scheduling of irrigation- different approaches, practicing use of instruments.
7.	Estimation of irrigation efficiency and water requirements of horticultural crops.
8.	Irrigation planning and scheduling.
9.	Soil moisture conservation practices.

Suggested Readings:

- Rao, Y.P. and Bhaskar, S.R. 2008. Irrigation Technology.
- Dilip Kumar Majumdar. 2004. Irrigation Water Management: Principles and Practices. Prentice Hall of India Pvt. Ltd.,
- S.V. Patil & Rajakumar, G. R., 2016. Water Management in Agriculture and Horticultural Crops.
- Satish serial publishing House, Delhi.
- Carr M. K. V. and Elias Fereres. 2012. Advances in Irrigation Agronomy. Cambridge University Press.
- Michael, A.M. 2015. Irrigation Theory and Practices. Vikas publishing house Pvt., Ltd.

31. AGR – 313 (Introduction to Major Field Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Classification of crops.
2.	Distribution of field crops.
3.	Definitions and concept of multiple cropping, mixed cropping, intercropping, relay and alley cropping,
4.	Cultural practices for raising major cereals (rice, wheat, maize, barley)
5.	Cultural practices for raising major pulses (pigeonpea, chickpea, urid, moong linneed etc.)
6.	Cultural practices for raising major oil seeds (soybean, mustard, groundnut etc.)
7.	Cultural practices for raising major fodder crops (berseem, lucern etc.)
8.	Green manuring and crop rotation.

Topics in Practical:

S. No.	Topics
1.	Identification of crop plants
2.	Identification of Seeds of crops
3.	Identification of weeds
4.	Preparation of cropping scheme
5.	Application of herbicides in field crops.

Suggested Readings:

- B. Gurarajan, R. Balasubramanian and V. Swaminathan. Recent Strategies on Crop Production. Kalyani Publishers, New Delhi.
- Chidda Singh.1997. Modern techniques of raising field crops. Oxford and IBH
- Publishing Co. Pvt. Ltd., New Delhi.
- Rajendra Prasad. Textbook of Field Crops Production - Commercial Crops. Volume II ICAR Publication.
- Rajendra Prasad. Textbook of Field Crops Production - Foodgrain Crops. Volume I ICAR Publication.
- S. R. Reddy. 2009. Agronomy of Field Crops. Kalyani Publishers, New Delhi.
- S. S. Singh. 2005. Crop Management. Kalyani Publishers, New Delhi.
- UAS, Bangalore. 2011. Package of Practice. UAS, Bangalore.
- Chidda Singh 1983. Modern Techniques of raising Field crops. Oxford & IBH, Publishing Co., New Delhi
- Rajendra Prasad 2002. Text Book of Field crops Production, ICAR, New Delhi.
- Reddy, S.R. 2004. Agronomy of Field crops, Kalyani Publishers, Ludhiana.
- Subhash Chandra Bose, M. and Balakrishnan, V. 2001. Forage Production South
- Asian Publishers, New Delhi.

32. AGR – 124 (Organic Farming)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction and concept of organic farming.
2.	Relevance in present context .
3.	Organic production requirements.
4.	Biological intensive nutrient management-organic manures, vermicomposting, green manuring.
5.	Recycling of organic residues.
6.	Biofertilizers; Soil improvement and amendments.

7.	Integrated diseases and pest management–use of biocontrol agents, biopesticides pheromones, trap crops, bird perches.
8.	Weed management .
9.	Quality considerations, certification, labeling and accreditation processors, marketing and exports.

Topics in Practical:

S. No.	Topics
1.	Raising of vegetable crops organically through nutrient, diseases and pest management.
2.	Vermicomposting.
3.	Vegetable and ornamental nursery raising.
4.	Macro quality analysis, grading, packaging, postharvest management.

Suggested Readings:

- A.K. Dahama. 2007. Organic farming for sustainable agriculture. Agrobios (India), Jodhpur.
- Arun. K. Sharma. 2011. Handbook of Organic farming. Agrobios (India), Jodhpur.
- Joshi, Mukund 2016. New Vistas of Organic Farming. Scientific Publishers
- S.P. Palaniappan and K. Annadurai. 2010. Organic farming – Theory and Practice. Scientific Publishers. Jodhpur.
- U. Thapa and P. Tripathy. 2006. Organic farming in India- Problems and Prospects. Agrotech publishing agency, Udaipur.
- G.K. Veeresh. 2006. Organic farming. Foundation Books. New Delhi.
- Purshit, S.S. 2006. Trendsin Organic Farming in India. Agros Bios (INDIA), Jodhpur.
- Thampan, P. K. 1995. Organic Agriculture. Peckay tree Crops Development Foundation, Cochin, Kerala.
- Sathe, T.V.2004. Vermiculture and Organic Farming. Days Publishing House, New Delhi

Department – Plant Protection

33. PPT – 211 (Fundamentals of Plant Pathology)

Credit Hours: 1 (1+0)

Topics in Theory:

S. No.	Topics
1.	Introduction to the science of phytopathology, its objectives, scope and historical background.
2.	Classification of plant diseases, symptoms, signs, and related terminology.
3.	Parasitic causes of plant diseases
4.	Fungi, their characteristics and classification.
5.	Bacteria, their characteristics and classification.
6.	Viruses their characteristics and classification.
7.	Phytoplasma general characteristics and Cell structures.
8.	Protozoa their characteristics and classification.
9.	Algae their characteristics and classification.
10.	Flowering parasitic plants their characteristics and classification.
11.	Non-parasitic causes of plant diseases.
12.	Infection process.
13.	Survival and dispersal of plant pathogens.
14.	Plant disease epidemiology, forecasting and disease assessment
15.	Principles and methods of plant disease management
16.	Integrated plant disease management.
17.	Fungicides classification based on chemical nature, commonly used fungicides, bactericides and nematicides

Topics in Practical:

S. No.	Topics
1.	Familiarity with general plant pathological laboratory and field equipments
2.	Study of disease symptoms and signs.
3.	Study of host parasite relationship.
4.	Identification and isolation of plant pathogens.
5.	Koch's postulates.
6.	Preparation of fungicidal solutions, slurries, pastes and their applications

Suggested Readings:

- N.G. Ravichandra, 2013.Fundamentals of Plant Pathology. PHI Hall of India, New Delhi
- R.S. Mehrohtra, Ashok Agarwal. Fundamental of Plant Pathology

- Sambamurthy A textbook of Plant Pathology
- R.S. Singh Introduction to principles of plant pathology
- Alexopoulos, C.J. Mims, C.W. and Blackwell, M.1996.Introduction to Mycology Wiley Eastern Ltd.
- Mandahar, C. L. 1987. Introduction to Plant Viruses. Chand and Co. Pvt. Ltd., New Delhi.
- Mehrotra, R. S. and Aneja,K.R.1990.An Introduction to Mycology. NewAge International(P), New Delhi.
- Singh, R.S. 1982. Plant Pathogens - The Fungi. Oxford and IBH Publishing Co., New Delhi.
- Singh, R.S. 1989. Plant Pathogens - The Prokaryotes .Oxford and IBH Publishing Co., New Delhi.
- Dhingra and Sinclair 1993. Basic Plant Pathology Methods. CBS,Publishers &Distributors, New Delhi.
- Agrios, G.N. 2006. Plant Pathology. Elsevier Academic press, London.
- The Plant Clinic by Erin Lovell Verinder 2022.

34. PPT – 222 (Diseases of Fruit, Plantation, Medicinal and Aromatic Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Etiology, symptoms, mode of spread, epidemiology and integrated
2.	management of the diseases of fruits, plantation, medicinal and aromatic crop of following diseases
3.	Mango: Powdery mildew, Anthracnose, Shooty mould ,Malformation and red rust of mango.
4.	Banana: Sigatoka leaf spot, Bunchy Top, Fusarium wilt or panama disease, Moko disease.
5.	Grape: Rust, Anthracnose, Powdery mildew and downy mildew of grapevines
6.	Citrus: Bacterial canker of citrus, Gummosis, Damping off of seedling , Shooty mould and Tristeza or Quick decline.
7.	Guava: Fruit rot of Guava, Guava wilt and Shooty mould
8.	Sapota: Leaf spot and Shooty mould
9.	Papaya: Collar rot , Leaf curl ,Papaya mosaic, Stem or Foot rot and Powdery mildew of papaya,
10.	Jack fruit: Pink disease and fruit rot
11.	Pineapple: Soft rot , Storage rot or fruit rot.
12.	Pomegranate: Leaf spot and fruit rot, Bacterial leaf spot
13.	Ber: Leaf spot (Alternaria sp.) and Powdery mildew of ber
14.	Apple: Apple scab, Powdery mildew, Crown gall ,Fruit rot and fire blight of apple.

15.	Pear: Fire blight, Peach leaf curl
16.	Peach: Leaf spot , Leaf curl, Powdery mildew
17.	Plum: Powdery mildew, Leaf spot .
18.	Almond: Blossom blight and Powdery mildew
19.	Walnut: Die back
20.	Strawberry: red stele, black root rot.
21.	Areca nut: Fruit rot and Nut fall
22.	Coconut: Fruit rot, Nut fall and Root rot or Wilt
23.	Oil palm: Basal stem rot(Ganoderma disease of oil palm , white rot)
24.	Coffee: Coffee rust , Damping off or Collar rot and Die back.
25.	Tea: Red rust , and Blister blight
26.	Cocoa: Seedling die back , Colletotrichum pod rot and Pink disease.
27.	Cashew: Damping off, Shooty mould, Anthracnose, Powdery mildew , rust

Topics in Practical:

S. No.	Topics
1.	Observations of disease symptoms,
2.	Identification of casual organisms and host parasite relationship of important diseases.
3.	Examination of scrapings and cultures of important pathogens of fruits
4.	Examination of scrapings and cultures of important pathogens of plantation crops
5.	Examination of scrapings and cultures of important pathogens of medicinal and aromatic crops

Suggested Readings:

- L.R. Verma and R.C. Sharma. Diseases of horticultural Crops-, Indus Publishers
- Srikant Kulkarni, Yashoda R. Hedge, Diseases of Plantation crops and their management-Agrotech Pub. Acd.
- S.L. Godara, BBS Kapoor, B.S. Rathore Disease management of spice crops-, Madhu Publications.
- Alfred Steferud Diseases of Plantation Crops-, Biotech books.
- L. Darwin Christdhar Henry and H. Lewin Devasahayam. Crop diseases: Identification, Treatment and Management. An Illustrated Handbook, New India publishing. Agency.
- Anna L Acolour atlas of Post Harvest Diseases & Disorders of fruits and vegetables Snowdon, CRC Press.
- Pathak, V.N. 1980.Diseases of Fruit Crops. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi.
- Ranga Swamy, G. 1988.Diseases of Crop Plants in India. Prentice Hall of India Pvt. Ltd., New Delhi.
- Singh, R.S. 1996.Plant Diseases. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi.
- Saha, L.R. 2002.Hand Book of Plant Diseases. Kalyani Publishers, New Delhi.

35. PPT – 323 (Diseases of Vegetable, Ornamental and Spice Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Etiology, symptoms, mode of spread, epidemiology and integrated management of diseases of the following vegetables, ornamental and spice crops:
2.	Tomato: Early blight ,Late blight , Leaf curl of tomato, Damping off of Seedling, Buckey rot or fruit rot, Bacterial wilt, Fusarium wilt, root knot and Virus disease ,.
3.	Brinjal: Phomopsis blight & fruit rot, Alternaria leaf spot, Damping of off seedling, Bacterial wilt, Little leaf and root knot.
4.	Chillis: Ripe fruit Bacterial wilt, & Anthracnose, Die back of chillis, Damping of off seedling, Powdery mildew ,Leaf curl , root knot.
5.	Bhindi: Powdery mildew, Yellow vein mosaic ,and root knot of Okra
6.	Cabbage, cauliflower, knol-khol : Club root of crucifers, Damping of off seedling, White Blister or white Rust of crucifers, Downy mildew of crucifers, Alternaria leaf spot of crucifers, Black rot, Brown rot ,Whiptail and buttoning.
7.	Pea: Downy mildew , Powdery mildew and Rust of pea
8.	Beans: Bean rust, Anthracnose of Bean, Mosaic and Powdery mildew, root knot
9.	Radish: Alternaria Blight (Alternaria raphani) ,root knot, club root.
10.	Beet root : Cercospora leaf spot, Downy mildew and beet mosaic.
11.	Onion: Purple blotch ,Downy mildew ,Smudge and bloat disease of onion ,
12.	Garlic: Purple blotch, White rot, Stemphylum blight and Powdery mildew
13.	Ginger : Rhizome rot or soft rot of Ginger
14.	Turmeric: Leaf spot, Rhizome rot or root rot of Turmeric .
15.	Potato: Early blight, Late blight, black scurf, Wart, Leaf roll ,Potato mosaic ,Potato spindle tuber disease and Cyst nematodes.
16.	Pepper(Black) : Foot rot and Wilt of peeper

Topics in Practical:

S. No.	Topics
1.	Observations of symptoms of important diseases of vegetables, ornamental and spice crops,
2.	Causal organisms and host parasitic relationship of important diseases,
3.	Examination of cultures of important pathogens of vegetable crops.
4.	Examination of cultures of important pathogens of ornamental crops.
5.	Examination of cultures of important pathogens of spice crops.

Suggested Readings:

- Srikant Kulkarni, Yashoda R. Hedge. Diseases of Plantation crops and their management-,

Agrotech publication Academy

- S.L. Godara, BBS Kapoor, B.S. Rathore. Disease management of spice crops-, Madhu Publications
- L. Darwin Christdhar Henry and H. Lewin Devasahayam Crop diseases: Identification, Treatment and Management. An Illustrated Handbook –, New India publishing Agency
- Singh, R.S. 1994. Diseases of Vegetable Crops. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi
- Singh, R.S 1996. Plant Diseases. Oxford IBH Publishing Co. Pvt. Ltd., New Delhi
- Sohi, H.S. 1992. Diseases of Ornamental plants in India. ICAR, New Delhi
- Ranga Swamy, G. 1988. Diseases of Crop Plants in India. Prentice Hall of India Pvt. Ltd., New Delhi.
- Saha, L.R. 2002. Hand Book of Plant Diseases. Kalyani Publishers
- Arjunan, G. Karthikeyan, G. Dinakaran, D. Raguchander, T. 1999. Diseases of Horticultural Crops. Dept. of Plant Pathology, Tamilnadu Agricultural University Coimbatore.

36. NEM – 211 (Nematode Pests of Horticultural Crops and Their Management)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	History of development of nematology - definition, economic importance.
2.	General characters of plant parasitic nematodes, their morphology,
3.	Taxonomy, classification of Plant parasitic nematodes
4.	Biology and symptomatology of plant Parasitic nematode
5.	Control of important plant parasitic nematodes of fruits (tropical, subtropical and temperate) crops
6.	Control of important plant parasitic nematodes of Vegetable and tuber crops.
7.	Control of important plant parasitic nematodes of ornamental crops
8.	Control of important plant parasitic nematodes of spice and plantation crops.
9.	Role of nematodes in plant disease complex.
10.	Integrated nematode management

Topics in Practical:

S. No.	Topics
1.	Methods of sampling and extraction of nematodes from soil and plant parts,
2.	Killing, fixing and preparation of temporary and permanent nematode mounts.
3.	Nematicides and their use.
4.	Collection and preservation of 20 plant species/parts damaged by plant parasitic nematodes.

Suggested Readings:

- Upadhyay, K.D and Dwivedi, K. 1997. A text book of plant nematology. Amman Publishing House Aman publishing house, Meerut
- Vasanth Raju David, B. 2001. Elements of economic entomology. Popular book Depot, Chennai.
- Gopal Swaroop and Das Gupta 1986.ICAR, New Delhi. Plant Parasitic Nematodes of India Problems and Progress.
- Nair, M.R.G.K. 1975. Insects and Mites of Crops in India. ICAR, New Delhi
- Metcalf, R.L and Luckman, W.H. 1982. Introduction to Insect pest management Wiley Inter Science Publishing, New York.
- Butani, D.K. 1984. Insects and Fruits. Periodical Expert Book Agency, New Delhi
- E.I. Jonathan, I. Cannayane, K. Devrajan, S. Kumar, S. Ramakrishan, Agricultural Nematology. TNAU, Coimbatore.
- Plant Disease Control by Y.L. Nene 2018. 4th edition

37. ENT – 211 (Fundamentals of Entomology)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to phylum arthropoda
2.	Importance of class Insecta
3.	Insect dominance
4.	History of entomology in India
5.	Importance of entomology in different fields
6.	Definition, division and scope of entomology
7.	Comparative account of external morphology-types of mouth parts
8.	Types of antennae
9.	Types of legs
10.	Wings-Hypothetical wing venation and modification
11.	Genitalia
12.	Structure and function of cuticle
13.	Moulting and body segmentation
14.	Anatomy of digestive systems
15.	Circulatory systems
16.	Sensory organs
17.	Respiratory system
18.	Glandular systems
19.	Excretory systems
20.	Nervous systems

21.	Reproductive systems
22.	Types of reproduction
23.	Postembryonic development-eclosion
24.	Matamorphosis
25.	Types of egg larvae
26.	Types of Pupa
27.	Classification of insects up to orders sub-order and families of economic importance and their distinguished characters
28.	Plant mites – morphological features, important families with examples.

Topics in Practical:

S. No.	Topics
1.	Insect collection and preservation
2.	Identification of important insects
3.	General body organization of insects
4.	Study on morphology of grasshopper or cockroach
5.	Preparation of permanent mounts of mouth parts
6.	Preparation of permanent mounts of antennae
7.	Preparation of permanent mounts of legs
8.	Preparation of permanent mounts of wings
9.	Dissection of grasshopper for study of internal morphology
10.	Dissection of caterpillar for study of internal morphology
11.	Observations on metamorphosis of larvae
12.	Observations on metamorphosis of pupae
13.	Dissection of cockroaches.

Suggested Readings:

- Awasthi, V.B. 1997. Introduction to general and applied entomology. Scientific Publishers, Jodhpur, 379 p.
- Borror, D.J., C.A. Triple Horn and N.F. Johnson. 1987. An introduction to the study of insects (VI Edition). Harcourt Brace College Publishers, New York, 875p.
- Chapman, R.F. 1981. The Insects: Structure and function. Edward Arnold (Publishers) Ltd, London, 919p.
- Gullan, P.J. and Cranston, P.S. 2001. The insects- An outline of entomology, II edition, Chapman & Hall, Madras, 491p.
- Mani, M.S. 1968. General entomology. Oxford and IBH Publishing Co. Pvt Ltd., New Delhi, 912p.
- Nayar, K.K., T.N. Ananthakrishnan and B.V. David. 1976. General and applied entomology, Tata McGraw Hill Publishing Company Limited, New Delhi, 589p.

- Richards, O.W. and R.G. Davies. 1977. Imm's general text book of entomology, Vol.1&2, Chapman and Hall Publication, London, 1345p.
- Romoser, W.S. 1988. The Science of Entomology, McMillan, New York, 449p.
- Saxena, S.C. 1992. Biology of insects. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 366p.
- Srivastava, P.D. and R.P. Singh. 1997. An introduction to entomology, Concept Publishing Company, New Delhi, 269p.

38. ENT – 313 (Apiculture, Sericulture and Lac culture)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to beneficial insects
2.	Importance and History of apiculture
3.	Species of honey bees, Rock bee, Little bee, Indian bee, European bee, Italian bee and Dammar bee, lifecycle and caste determination
4.	Bee colony maintenance, bee colony activities, starting of new colony, location site, transferring colony, replacement of queen, combining colonies, swarm prevention
5.	Colony management in different seasons
6.	Equipment for apiary, types of bee hives and their description
7.	Bee pasturage. Honey extraction, honey composition and value, bee wax and tissues
8.	Importance, History and development of sericulture in India, silkworms kinds and their hosts, systematic position, distribution, lifecycles in brief, Silk glands
9.	Mulberry silkworm-morphological features, races, rearing house and equipments, disinfection and hygiene
10.	Grainage acid treatment, packing and transportation of eggs, Incubation, black boxing, hatching of eggs.
11.	Young age rearing /chawki rearing and old age rearing of silkworms
12.	Feeding, spacing, environmental conditions and sanitation. Cocoon characters- colour, shape, hardiness and shell ratio.
13.	Defective cocoons and stifling of cocoons. Uses of silk and by-products. Economics of silk production. Moriculture-Mulberry varieties, package of practices, Pests and diseases and their management
14.	Lac growing areas in India, Lac insects, biology, behaviour, lac cultivation, food plants, pruning, inoculation, cropping, kinds of lac.
15.	Enemies of lac-insects.

Topics in Practical:

S. No.	Topics
1.	Honey bee colony, different bee hives and apiculture equipments.

2.	Summer and Winter management of colony.
3.	Honey extraction and bottling
4.	Study of pests and diseases of honeybees
5.	Establishment of mulberry garden
6.	Preparation of mulberry cuttings, planting methods under irrigated and rain fed conditions
7.	Maintenance of mulberry garden-pruning, fertilization, irrigation and leaf harvest
8.	Mulberry pests and diseases, their management and nutritional disorders
9.	Study of different kinds of silkworms and mulberry silkworm morphology, silk glands. Sericulture equipments for silkworm rearing.
10.	Mulberry silkworm rearing, room requirements, Rearing of silkworms-chawki rearing
11.	Rearing of silkworms -late age silkworm rearing and study of mountages
12.	Study of silkworm pests and their management.
13.	Study of silkworm diseases and its management
14.	Lac insects-biology, behaviour, lac cultivation, food plants, pruning, inoculation, cropping, kinds of lac.
15.	Enemies of lac insects.

Suggested Readings:

- Singh, S., 1975. Bee keeping in India – ICAR, New Delhi., 214p.
- Sunita, N.D, Guled ,M.B, Mulla S.R and Jagginavar,2003, Beekeeping, UAS Dharwad
- Mishra, R.C. and Rajesh Gar. 2002. Prospective in Indian Apiculture. Agrobios, Jodhpur.
- Singh, D and Singh, D.P. 2006. A hand book of Beekeeping, Agrobios (India).
- Paul DeBach and Devid Rosen 1991. Biological control by natural enemies. Cambridge University Press; 2 edition (27 June 1991)
- YA Shinde and BR Patel. Sericulture in India
- Tribhuwan Singh. Principles and Techniques of Silkworm Seed Production, Discovery publishing House Pvt. Ltd
- M.L. Narasaiah. Problems and Prospects of Sericulture. discovery publishing House Pvt. Ltd.
- Ganga,G. and Sulochana Chetty, J. 1997. An introduction to Sericulture (2nd Edn.). Oxford & IBH publishing Co. Pvt. Ltd., New Delhi.
- Krishnaswamy, S. (Ed). 1978. Sericulture Manual - Silkworm Rearing. FAO Agrl. Services bulletin, Rome.

39. ENT – 222 (Insect Pests of Fruit, Plantation, Medicinal & Aromatic Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	General – economic classification of insects

2.	Bio-ecology and insect-pest management with reference to fruit, plantation, medicinal and aromatic crops
3.	pest surveillance
4.	Distribution, host range, bio-ecology, injury and integrated management of important insect pests affecting tropical fruits
5.	Distribution, host range, bio-ecology, injury and integrated management of important insect pests affecting sub-tropical fruits
6.	Distribution, host range, bio-ecology, injury and integrated management of important insect pests affecting temperate fruits
7.	Distribution, host range, bio-ecology, injury and integrated management of important insect pests affecting plantation crops- coconut, areca nut, oil palm, cashew, cacao, tea, coffee, cinchona, rubber, betel vine etc
8.	Distribution, host range, bio-ecology, injury and integrated management of important insect pests affecting medicinal and aromatic crops- senna, neem, belladonna, pyrethrum, costus, crotalaria, datura, dioscorea, mint, opium, *Solanum khasianum* etc
9.	Storage insects – distribution, host range, bio-ecology, injury and integrated management of important insect pests attacking stored fruits crops their processed products
10.	Storage insects – distribution, host range, bio-ecology, injury and integrated management of important insect pests attacking stored plantation crops and their processed products
11.	Storage insects – distribution, host range, bio-ecology, injury, integrated management of important insect pests attacking stored medicinal and aromatic crops and their processed products
12.	Insecticide residue problems in fruit, plantation, medicinal and aromatic crops and their maximum residue limits (MRLs).

Topics in Practical:

S. No.	Topics
1.	Study of symptoms of damage collection, identification, preservation, assessment of damage
2.	Population of important insect – pests affecting fruits in field
3.	Population of important insect – pests affecting plantation in field
4.	Population of important insect – pests affecting medicinal and aromatic crops in field
5.	Population of important insect – pests affecting fruits, plantation, medicinal and aromatic crops in storage.

Suggested Readings:

- Reddy, P. P., 2010, Plant Protection in Horticulture Vol. 1, 2 & 3, Scientific Publishers, Jodhpur.
- Ranjit, P. 2012, Entomological Techniques in Horticultural Crops, New India Publishing Agency.
- Nair M R G K, 1995, Insect and Mites of Crops in India, ICAR, New Delhi.
- Ayyar, T.V.R. 1963. Hand book of entomology for south India. Govt. press Madras, 516p.
- David B V and Kumarswami, T, 1982. Elements of Economic Entomology. Popular Book

Department, Madras, 536p.

- David. V. Alford. Pest of fruit crops. A. M. Ranjith. Identification and management of Horticultural pest.
- Rachna and Benna kumari. Pest management and residual analysis in horticultural crop
- K. P. Srivastav and Y. S. Ahawat. Pest management in citrus
- Ramnivas Sharma. Identification and management of horticulture pest.
- Fryer. Insect pest of fruit crops S. Atwal. Agricultural pests of south Asia and their management Mark Vernon Slingerland and C. R. Crosby. Manual of fruit insects
- Metcalf,R.LandLuckman,W.H.1982. Introduction to Insect pest management. Wiley Inter Science Publishing ,New York
- Butani,D.K.1984. Insects and Fruits. Periodical Expert Book Agency, New Delhi

40. ENT – 324 (Insect Pests of Vegetable, Ornamental and Spice Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Economic importance of insects in vegetable crops
2.	Economic importance of insects in ornamental crops
3.	Economic importance of insects in spice crops
4.	Ecology and pest management with reference to vegetable crops
5.	Ecology and pest management with reference to ornamental crops
6.	Ecology and pest management with reference to spice crops
7.	Pest surveillance in important vegetable, ornamental and spice crops
8.	Distribution, host range, bio-ecology, injury, integrated management of important insect-pests affecting vegetables
9.	Distribution, host range, bio-ecology, injury, integrated management of important insect-pests affecting ornamental crops
10.	Distribution, host range, bio-ecology, injury, integrated management of important insect-pests affecting spice crops
11.	Important storage insect-pests of vegetable, ornamental and spice crops and their host range, bio-ecology, injury and integrated management
12.	Insect –pests of processed vegetables and ornamental crops, their host range, bio-ecology, injury and integrated management
13.	Insecticidal residue problems in vegetables and ornamental crops, tolerance limits etc.

Topics in Practical:

S. No.	Topics
1.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting vegetable crops in field
2.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting ornamental crops in field
3.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting spice crops in field
4.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting vegetable crops during storage
5.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting ornamental crops during storage
6.	Study of symptoms, damage, collection, identification, preservation and assessment of damage of important insect pest affecting spice crops during storage
7.	Population of important insect-pests affecting vegetable crops in field
8.	population of important insect-pests affecting ornamental crops in field
9.	Population of important insect-pests affecting spice crops in field
10.	Population of important insect-pests affecting vegetable crops during storage
11.	Population of important insect-pests affecting ornamental crops during storage
12.	Population of important insect-pests affecting spice crops during storage

Suggested Readings:

- Reddy, P. P., 2010, Plant Protection in Horticulture Vol. 1, 2 & 3, Scientific Publishers, Jodhpur
- Ranjit, P., 2012, Entomological Techniques in Horticultural Crops, New India Publishing Agency.
- Nair M R G K, 1995, Insect and Mites of Crops in India, ICAR, New Delhi.
- Ayyar, T.V.R. 1963. Hand book of entomology for south India. Govt. press Madras, 516p.
- David B V and Kumarswami, T, 1982. Elements of Economic Entomology. Popular Book Department, Madras, 536p.
- P. Srivastava, Dhamo K. Butani Pest management in vegetables – Part1. Researcho Book Centre, 1998
- K.P. Srivastava, Dhamo K. Butani Pest management in vegetables – Part-2. Researcho Book Centre, 1998
- Rachna and Benna kumari. Pest management and residual analysis in horticultural crop
- Ramnivas Sharma. Identification and management of horticulture pest.
- T. V. Sathe. Pests of ornamental plants.
- S. Atwal. Agricultural pests of south Asia and their management
- Metcalf,R.LandLuckman,W.H.1982. Introduction to Insect pest management. Wiley Inter Science Publishing, New York

Department – Post Harvest Technology

41. PHM – 211 (Fundamentals of Food Technology)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Food and its function, physico-chemical properties of foods
2.	Food preparation techniques, nutrition, relation of nutrition of good health.
3.	Characteristics of well and malnourished population.
4.	Energy, definition, determination of energy requirements, food energy, total energy needs of the body.
5.	Mineral nutrition: macro minerals, function, utilization, requirements, sources, effects of deficiency.
6.	Micro-minerals (Ca, Fe and P) function, utilization, requirements, sources, effects of deficiency
7.	Vitamins: functions, sources, effects of deficiency, requirements of water soluble and fat-soluble vitamins.
8.	Balanced diet: recommended dietary allowances for various age groups.
9.	Assessment of nutritional status of the population.

Topics in Practical:

S. No.	Topics
1.	Methods of measuring food ingredients.
2.	Effect of cooking on volume and weight, determination of percentage of edible portion.
3.	Browning reactions of fruits and vegetables.
4.	Microscopic examination of starches.
5.	Estimation of energy, value proteins and fats of foods.
6.	Planning diet for various age groups.

Suggested Readings:

- Dr. Swaminathan, M.1985. Food and Nutrition Vol. I & II. BAPPCO, Bangalore.
- Dr. Swaminathan, M. 1985. Essential of Food and Nutrition Vol. II. BAPPCO, Bangalore.
- Manoranjan, K. and Sangita, S. 1996. Food Preservation and Processing. Kalyani Publishers 978-81-272-4262-6.
- Srilakshmi. 2010. Food Science. New age International 978-81-224-2724-0.
- Srilakshmi. 2005. Dietetics. New age International 978-81-224-1611-4.
- Shankunthala, M. 1972. Foods-Facts, Principles & Procedure. The Eastern Press, Bengaluru.
- Passmore, R. and Eastwood, M. A. 1986. Human Nutrition & Dietetics. ELBS.
- Anita, T. 1996. Food and Nutrition. Oxford 0198327668.

- Devendra, K. B. and Priyanka, T. 2006. An Introduction to Food Science and technology and Quality Management. Kalyani Publishers 81-272-2521-5.
- Monoranjam, K. and Sangita, S. 2008. Food Preservation and Processing. Kalyani Publishers 978-81-272-4262-6.
- George, I. S. and Dennis, D. L. 1994. Chemistry for the Health Science. MacMillan 0-02-405161-6.
- Masferton and Hurley. 1989. Chemistry Principles and Reactions. Saunders Golden Sunburst 0-03-005889-9.
- Bettelheim and March. 1984. Introduction to General, Organic & Biochemistry. Harcourt Brace college Puplishers 0030202175 Sounders college Puplishing.
- Gopalan, G., Ramasastri, B.V. and Balasubramnian, S. C. 1989. Nutritive valve of the Indian Foods. National Institute of Nutrition, ICMR, Hyderabad.
- http://www.fao.org/infoods/ y Swaminathan, M. 1988. Hand book of Food Science & Experimental Foods. Bappco publishers, Bangalore.
- Manay, S.N, Shadaksharaswamy, M.1998. Food-facts & Principles New Age International Publishers, New Delhi.
- Srilakshmi, B. 1995. Food Science. New Age International Publishers, New Delhi.

42. PHM – 322 (Post Harvest Management of Horticultural Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Importance of Postharvest Technology of horticultural crops.
2.	Maturity indices, harvesting, handling of horticultural crops.
3.	Grading of fruits vegetables, cut flowers.
4.	Grading in Plantation crops, spices, medicinal and aromatic plants.
5.	Pre-harvest factors affecting quality of horticultural crops.
6.	Factors responsible for deterioration of horticultural produces.
7.	Physiological and bio-chemical changes in horticultural crops.
8.	Hardening and delaying ripening process in Horticulture produce.
9.	Postharvest treatments of horticultural crops .
10.	Quality parameters and specifications of Horticulture produce.
11.	Structure of fruits, vegetables and cut flowers related to physiological changes after harvest.
12.	Methods of storage for local and Export market.
13.	Pre-harvest treatments and pre-cooling in horticultural produce.
14.	Pre-storage and storage of horticultural produce.
15.	Different systems of storage of horticultural produce.
16.	Packaging methods and types of packages used in Horti. Industries

17.	Recent advances in packaging.
18.	Types of containers and cushioning materials used horticultural items.
19.	Vaccum packaging in horticultural produces.
20.	Cold storage, poly shrink packaging in horticultural produces.
21.	Grape guard packing treatments.
22.	Modes of transport

Topics in Practical:

S. No.	Topics
1.	Practice in judging the maturity of various horticultural produce.
2.	Determination of physiological loss in weight in horticultural crops.
3.	Determination of quality and its loss in horticultural crops.
4.	Grading of horticultural produce.
5.	Post-harvest treatment of horticultural crops.
6.	Physical and chemical methods used for quality improvement in horticultural crops.
7.	Packaging in horticultural commodities.
8.	Storage and its types used for horticultural commodities.
9.	Post-harvest disorders in horticultural produce.
10.	Identification of storage pest and disease in spices
11.	Visit to markets Packing houses and cold storage units
12.	Practice in judging the maturity of various horticultural produce.
13.	Determination of physiological loss in weight in horticultural crops.
14.	Determination of quality and its loss in horticultural crops.

Suggested Readings:

- Verma, L. R. and Joshi, V. K. 2000. Post Harvest Technology of Fruits and Vegetables. Vol. I & II. Indus Publishing Co., New Delhi
- Wiils, McGlasson and Graham, J. 2007. Post Harvest- An Introduction to the Physiology and Handling of Fruits, Vegetables and ornamentals. Cab International
- Stanley, J. K. 1998. Post Harvest Physiology of Perishable Plant Products. CBS, New Delhi.
- Neetu Sharma and Mashkoor Alam,
- Chadha, K. L. and Kalloo, G.1993. Advances in Horticulture. Vol. 4 to 10. MPH, New Delhi.
- Hulme, A.C. 1970. Food Science & Technology - A Series of Monograph. The Biochemistry of Fruits and their Products. Vol.-1. Academic Press London & New York.
- Mitra, S. K. 1997. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CAB International.
- Fellows, P. J. 1998. Food Processing Technology – principles and Practices. Ellis Horwood.
- Thomposon, A. K. 1996. Post harvest Technology of Fruits and Vegetables. Blackwell Science.

43. PHM – 323 (Processing of Horticultural Crops)

Credit Hours: 3 (1+2)

Topics in Theory:

S. No.	Topics
1.	Importance and scope of fruit and vegetable preservation industry in India
2.	Food pipe line: Losses in post-harvest operations, unit operations in food processing.
3.	Principles and guidelines for the location and establishment of processing units in India
4.	Principles and methods of preservation by heat- pasteurization, Canning of fruits and vegetables
5.	Methods of preparation of Juices, RTS, Nectar, Squashes, Cordials, Syrups
6.	Fermented beverages
7.	Methods of preparation of Jam, Jelly and Marmalade
8.	Preservation by using sugar and chemical preservatives
9.	Methods of preparation of candies, preserves, crystallized fruits
10.	Preservation with salt and vinegar
11.	Methods of preparation of pickles
12.	Methods of preparation of Chutneys and Sauces
13.	Methods of preparation of Tomato and mushrooms products
14.	Freezing preservation
15.	Processing of plantation crops and their products
16.	Spoilage in processed fruits and vegetables
17.	Quality control of processed products
18.	Govt. policy on import and export of processed fruit products
19.	Food laws.

Topics in Practical:

S. No.	Topics
1.	Equipments used in food processing units
2.	Physico-chemical analysis of fruits and vegetables
3.	Canning of fruits and vegetables
4.	Preparation of RTS, nectar, squash, cordial, syrup
5.	Preparation of jam, jelly, marmalade
6.	Preparation of fruit chutneys, sauces, pickles (hot and sweet)
7.	Preparation of candies and preserves
8.	Dehydration of fruits and vegetables, tomato product dehydration
9.	Refrigeration and freezing of fruit and vegetables
10.	Processing of plantation crops

11.	Cut-out analysis of processed foods
12.	Visit to processing units

Suggested Readings:

- Verma, L. R. and Joshi, V. K. 2000. Post Harvest Technology of Fruits and Vegetables. Vol. I & II. Indus Publishing Co., New Delhi.
- Dauthy, M. E. 1995. Fruits and Vegetables Processing- FAO Bulletin 119. International Book Distributing Co., Lucknow.
- Srivastava, R. P. & Sanjeev Kumar. 2002. Fruits and vegetable Preservation – Principles and Practice. International Book Distributing Co., Lucknow.
- Salunkhe, D.K., Bolin, H. R. and Reddy, N. R. 1991. Storage, Processing and Nutritional Quality of Fruits and Vegetables. 2nd Edition. Vol. II. CRC Press
- Neetu Sharma and Mashkoor Alam, M. 1998. Post Harvest Disease of Horticultural Perishable. International Book Distributing Co., Lucknow
- Chadha, K. L. and Kalloo, G.1993. Advances in Horticulture. Vol. 4 to 10. MPH, New Delhi
- Fellows, P. J. 1998. Food Processing Technology – principles and Practices. Ellis Horwood.
- Manoranjan, K and Sangita, S. 1996. Food Preservation & Processing. Kalyani Publishers, India.
- Vijay, K. 2001. Text Book of Food Sciences and Technology. ICAR, New Delhi.
- Siddappaa, G. S., Girdhari Lal and Tandon, G.L. 1998. Preservation of Fruits and Vegetables. ICAR, New Delhi
- FAO - Training Manual No.17/2. 2007. Prevention of post harvest food losses: Fruits, Vegetables and Root crops. Daya Publishing House, Delhi.
- Morris, T. N. 2006. Principles of Fruit Preservation. Biotech Books, Delhi.
- Khan, K. A., Goyal, M. R., and Kalne, A. A. 2018. Processing of Fruits and Vegetables: From Farm to Fork. In Book Series: Innovations in Agricultural and Biological Engineering, Apple Academic Press, USA.
- Srivastava,R. P.andSanjeevK.1998. Fruit and vegetable preservation principles practice. International Book Distributing Co.,Lucknow.
- Girdharilal, Siddappa, G. S. and Tandon, G. L.1998. Preservation of fruits and vegetables. ICAR, New Delhi.
- Dauthy and Mircea, E.1995. Fruit and vegetables processing. International Book Distribution Co, Lucknow.
- Kaysand Stanely,J. 1998. Postharvest physiology of perishable plant products. CBS Publishers, Distributors, New Delhi
- Bhatti, S 1995.Vame, Fruit and vegetable processing. CBS Publishers, Distributors, NewDelhi.

- Salunkhe, D.K., Bolin, H. R. and Reddy, N. R. 1991. Storage, Processing and Nutritional Quality of Fruits and Vegetables. 2nd Edition. Vol. II. CRC Press
- Neetu Sharma and Mashkoor Alam, M. 1998. Post Harvest Disease of Horticultural Perishable. International Book Distributing Co., Lucknow
- Chadha, K. L. and Kalloo, G.1993. Advances in Horticulture. Vol. 4 to 10. MPH, New Delhi
- Fellows, P. J. 1998. Food Processing Technology – principles and Practices. Ellis Horwood.

Department – Vegetable Science

44. VSC – 121 (Tropical and Subtropical Vegetables Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Area, production, economic importance and export potential of tropical and sub-tropical vegetable crops.
2.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, spacing, planting systems, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of tomato
3.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, spacing, planting systems, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting yield, economics of cultivation, post-harvest handling, storage and marketing of brinjal
4.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, spacing, planting systems, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting yield, economics of cultivation, post-harvest handling, storage and marketing of chilli
5.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, spacing, planting systems, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting yield, economics of cultivation, post-harvest handling, storage and marketing of capsicum/Shimla Mirch
6.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, seed treatment, sowing, spacing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting yield, economics of cultivation, post-harvest handling, storage and marketing of okra
7.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of Amaranthus,
8.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of cluster bean,
9.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting,

	yield, economics of cultivation, post-harvest handling, storage and marketing of cowpea.
10.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of lablab bean.
11.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of snap bean.
12.	General description about cucurbits. Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, sowing, spacing, planting systems, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of cucumber.
13.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of bitter gourd.
14.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; transplanting, sowing, spacing, planting systems, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of bottle gourd.
15.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of sponge gourd.
16.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of ridge gourd.
17.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, methods of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of watermelon
18.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, methods of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing

	of muskmelon
19.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of summer squash,
20.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of winter squash
21.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of pumpkin
22.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, time of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of round melon
23.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, sowing, spacing, methods of sowing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of long melon
24.	Description of varieties and hybrid, climate and soil requirements, preparation of field, nursery practices, planting, spacing, time of planting, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of ivy gourd
25.	Description of varieties and hybrid, climate and soil requirements, preparation of field, nursery practices, planting, spacing, time of planting, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of pointed gourd,
26.	Description of varieties and hybrid, climate and soil requirements, preparation of field, nursery practices, planting, spacing, time of planting, methods of planting, staking, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of spine gourd
27.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, method of propagation, nursery raising, planting, spacing, planting systems, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of moringa

28.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, method of propagation, nursery raising, planting, spacing, planting systems, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of curry leaf
29.	Description of varieties and hybrid, climate and soil requirements, seed rate, preparation of field, nursery practices; sowing, time of sowing, spacing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of portulaca
30.	Description of varieties, climate and soil requirements, preparation of field, sowing, seed rate, spacing, planting systems, staking, water and weed management, nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, post-harvest handling, storage, marketing and economics of cultivation of basella.
31.	Description of varieties, climate and soil requirements, seed rate, preparation of field, sowing, seed rate, spacing, water and weed management; nutrient management and deficiencies, use of chemicals and growth regulators, cropping systems, harvesting, yield, economics of cultivation, post-harvest handling, storage and marketing of sorrel and roselle

Topics in Practical:

S. No.	Topics
1.	Identification and description of tropical and sub-tropical vegetable crops
2.	Nursery practices and transplanting of tropical and sub-tropical vegetable crops
3.	Preparation of field for tropical and sub-tropical vegetable crops
4.	Sowing/planting for direct sown and planted tropical and sub-tropical vegetable crops
5.	Herbicide use in tropical and sub-tropical vegetable crops
6.	Top dressing of fertilizers in tropical and sub-tropical vegetable crops
7.	Intercultural operations in tropical and sub-tropical vegetable crops
8.	Use of growth regulators in tropical and sub-tropical vegetable crops
9.	Identification of nutrient deficiencies, physiological disorders in tropical and sub-tropical vegetable crops
10.	Harvest indices and maturity standards in tropical and sub-tropical vegetable crops
11.	Harvesting in tropical and sub-tropical vegetable crops
12.	Post-harvest handling, storage and marketing of tropical and sub-tropical vegetable crops
13.	Cost of cultivation for tropical and sub-tropical vegetable crops
14.	Project preparation for commercial cultivation of tropical and sub-tropical vegetables

Suggested Readings:

- S. Thamburaj, 2014. Text Book of Vegetable, Tuber crops and Spices. ICAR, New Delhi

- B.R. Choudhary, 2009. A text Book on Production Technology of Vegetables. Kalyani Publishers. Ludhiana.
- T.K. Bose, 2002.Vegetable Crops. Naya prakash. Kolkata
- T. R. Gopal Krishnan, 2007. Vegetable Crops. New India Publishing Agency. New Delhi.
- K.V. Kamath, 2007.Vegetable Crop Production. Oxford Book Company. Jaipur
- M.S. Dhaliwal, 2008. Handbook of Vegetable Crops. Kalyani Publishers. Ludhiana
- Singh, Umashankar, 2008. Indian Vegetables. Anmol Publications. Pvt. Ltd .New Delhi.
- K S Yawalkar, 2008. Vegetable crops in India. Agri-Horticultural Pub. House. Nagpur. 2004
- M.K. Rana, 2008.Olericulture in India. Kalyani Publishers. Ludhiana
- P. Hazra, 2006.Vegetable Science. Kalyani Publishers. Ludhiana
- Pratibha Sharma, 2007.Vegetables: Disease Diagnosis and Biomanagement. Avishkar Publishers. Jaipur
- Nath Prem, 1994.Vegetables for the Tropical Regions. ICAR New Delhi
- K.L. Chadha, 1993. Advances in Horticulture. Malhotra publishing house. New Delhi
- Shanmugavelu, K.G., 1989. Production Technology of Vegetable Crops. Oxford &IBH Publishing Co. Pvt. Ltd, New Delhi.
- Choudhury, B. (ICAR). 1990. Vegetables. 8th edition, National Book Trust, New Delhi.
- Singh, D.K., 2007. Modern Vegetable varieties and production. IBN publishers, Technology International Book Distributing Co, Lucknow.
- Singh, S.P. 1989. Production Technology of Vegetable Crops. ARCC, Sadar Karnal
- Chadha, K.L. 2001. Hand Book of Horticulture. ICAR, New Delhi
- Hazra, P.; Chattopadhyay, A.; Karmakar, K. and Dutta S. 2011. Modern Technology in Vegetable Production. NIPA, New Delhi
- Mourya, K.R. 2012. “Bharat Ki Salad Phasalen” Satish Serial Publishing House, Azadpur, Delhi.
- Nath, Prem and Swamy, KRM. 2016. Text Book of Vegetable Crops. ICAR, New Delhi

45. VSC – 212 (Temperate Vegetable Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Importance of temperate vegetable crops in nutrition and national economy
2.	Cabbage and Chinese cabbage: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
3.	Cauliflower: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
4.	Knol khol: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
5.	Sprouting broccoli and Brussels’ sprout: Area, production, export potential, description

	of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
6.	Lettuce and Vegetable kale: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
7.	Spinach and Palak: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and Marketing
8.	Garlic: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
9.	Onion: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
10.	Leek: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
11.	Radish: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
12.	Carrot: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
13.	Turnip and Beet root: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
14.	Peas: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
15.	Broad bean: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
16.	Rhubarb: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
17.	Asparagus: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing
18.	Globe artichoke: Area, production, export potential, description of varieties and hybrids, origin, climate and soil, production technologies, post-harvest technology and marketing

Topics in Practical:

S. No.	Topics
1.	Identification and description of varieties/hybrids of cole crops
2.	Identification and description of varieties/hybrids of root crops
3.	Identification and description of varieties/hybrids of temperate , leafy and other vegetable crops
4.	Propagation method of temperate vegetable crops
5.	Nursery management temperate vegetable crops
6.	Preparation of field for sowing/planting temperate vegetable crops

7.	Sowing/transplanting practice
8.	Identification of physiological and nutritional disorders and their corrections
9.	Post-harvest handling of temperate vegetable crops
10.	Cost of cultivation of temperate vegetable crops
11.	Field visits to commercial farms

Suggested Readings:

- S. Thamburaj. 2014. Text Book of Vegetable, Tuber crops and Spices. ICAR, New Delhi.
- B.R. Choudhary 2009.AText Book on Production Technology of Vegetables. Kalyani Publishers. Ludhiana.
- T.K.Bose. 2002.Vegetable Crops. Nayaprakash. Kolkata
- P. Hazra. 2011. Modern Technology in Vegetable Production. New India Publishing Agency.
- New Delhi.
- T.R.Gopal Krishnan, 2007. Vegetable Crops. New India Publishing Agency. New Delhi.
- K.V.Kamath. 2007.Vegetable Crop Production. Oxford Book Company. Jaipur
- M.S.Dhaliwal, 2008.Handbook of Vegetable Crops. Kalyani Publishers. Ludhiana
- Singh, Umashankar, 2008. Indian Vegetables. Anmol Publications. Pvt.Ltd .New Delhi.
- K S Yawalkar, 2004.Vegetable crops in India. Agri-Horticultural Pub. House. Nagpur.
- M.K. Rana, 2008.Olericulture in India. Kalyani Publishers. Ludhiana
- P. Hazra. 2006.Vegetable Science. Kalyani Publishers .Ludhiana
- Pratibha Sharma, 2007.Vegetables: Disease Diagnosis and Biomanagement. Avishkar
- Publishers. Jaipur
- Uma Shankar. 2008. Vegetable Pest Management Guide for Farmers. International Book Distribution Co. Publication. Lucknow.
- Nath Prem. 1994.Vegetables for the Tropical Regions. ICAR New Delhi
- K.L. Chadha. 1993.Advances in Horticulture. Malhotra publishing house. New Delhi
- Shanmugavelu, K.G. 1989. Production technology of vegetable crops. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
- Bose, T.K. 2003. Vegetable Crops. Naya udyog publishers, Kolkata. 2002. Naya Prakash,
- Prem Singh Arya, 1999. Vegetable Seed Production Principles. Kalyani Publishers, New Delhi.
- Choudhery, B., 1990. Vegetables. 8th edition. National Book Trust, New Delhi.

46. VSC – 223 (Precision Farming and Protected Cultivation)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Precision farming – concept of precision farming, importance and need, principles,
2.	Laser leveling,

3.	Mechanized direct seed sowing
4.	Seedling and sapling transplanting
5.	Mapping of soils and plant attributes
6.	Site specific input application
7.	Weed management
8.	Insect pests and disease management
9.	Yield mapping in horticultural crops
10.	Introduction of Green house technology
11.	Types of Green Houses
12.	Plant response to Greenhouse environment
13.	Planning and design of greenhouses
14.	Design criteria of greenhouse for cooling and heating purposes
15.	Green house equipments
16.	Material of construction for traditional and low-cost green houses
17.	Irrigation systems used in greenhouses
18.	Typical applications, passive solar green house, hot air greenhouse heating systems,
19.	Green house drying
20.	Cost estimation and economic analysis
21.	Choice of crops for cultivation under greenhouses
22.	Problems/constraints of greenhouse cultivation and future strategies.
23.	Growing media, soil culture, type of soil required,
24.	Drainage, flooding and leaching,
25.	Soil pasteurization in peat moss and mixtures, rock wool and other inert media,
26.	Nutrient film technique (NFT)/hydroponics.

Topics in Practical:

S. No.	Topics
1.	Study of different types of greenhouses based on shape
2.	Study of different types of construction and cladding materials
3.	Calculation of air rate exchange in an active summer cooling system
4.	Estimation of drying rate of agricultural products inside green house
5.	Testing of soil to study its suitability for growing crops in greenhouses
6.	Testing of water to study its suitability for growing crops in greenhouses
7.	The study of fertigation requirements for greenhouses crops
8.	Estimation of E.C. in the fertigation solution
9.	The study of various growing media used in raising of greenhouse crops
10.	Preparation of various growing media used in raising of greenhouse crops and their

	pasteurization/sterilization
11.	Nursery raising of vegetable crops in protected structures
12.	Use of walk-in tunnels and low tunnels for vegetable cultivation
13.	Visit to commercial green houses
14.	Economics of protected cultivation

Suggested Readings:

- Balraj Singh. 2006. Protected Cultivation of Vegetable Crops. Kalyani Publishers, Ludhiana.
- Brahma Singh, 2014. Advances in Protected Cultivation. New India Publishing Agency. New Delhi.
- Reddy P. Parvatha, 2003. Protected Cultivation. Springer Publications. USA.
- Reddy, P. Parvatha. 2011. Sustainable Crop Protection under Protected Cultivation. Springer Publications. USA.
- Jitendra Singh, 2015. Precision Farming in Horticulture. New India Publishing Agency. New Delhi.
- Prasad S. 2005. Greenhouse Management for Horticultural Crops. Agrobios. Jodhpur.
- Jitendra Singh, S.K. Jain, L.K. Dashora, B.S. Cundawat.2013. Precision forming in Horticulture. New India Publishing Agency, New Delhi.
- T. Pradeep Kumar, B. Suma, Jyothi Bhaskar and K.N. Satheson. 2008. Management of Horticultural crops. New India Publishing Agency, New Delhi.
- Aldrich RA & Bartok JW. 1994. NRAES, Riley, Robb Hall. Green House Engineering. Cornell University, Ithaca, New York.
- Pant V Nelson. 1991. Green House Operation and Management. Bali Publ
- Srinivasan, Ancha (2006). Handbook of Precision Agriculture Principles and Applications, Taylor & Francis
- Zhang, Qin (2015). Precision Agriculture Technology for Crop Farming, CRC Press
- Krishna, K.R. (2016). Precision Farming Soil Fertility and Productivity Aspects, CRC Press
- Pedersen, Soren Marcus; Lind, Kim Martin (2017). Precision Agriculture: Technology and Economic Perspectives, Springer
- Tiwari, G.N. 2003. Greenhouse Technology for Controlled Environment. Narosa Publishing House, New Delhi.

47. VSC – 224 (Spices and Condiments)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	History, scope and importance, present status, area and production, uses, export potential and role of spices and condiments in national economy.
2.	Cardamom: Classification, soil and climate, propagation-seed, vegetative and micropropagation systems, sowing and methods of planting, varieties, nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
3.	Pepper: Classification, soil and climate, propagation-seed, vegetative and micro propagation systems, sowing and methods of planting, varieties, nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
4.	Betel vine: Classification, soil and climate, propagation-seed, vegetative and micro propagation systems, sowing and methods of planting, varieties, nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
5.	Ginger: Classification, soil and climate, propagation-seed, vegetative and micro propagation systems and methods of planting, varieties, nutritional management, irrigation practices, weeds control, mulching, earthing-up and cover cropping. Role of growth regulators, shade crops and shade regulation.
6.	Turmeric: Classification, soil, climate and varieties, propagation-seed, vegetative and micro propagation systems and methods of planting sowing spacing. Nutritional management, irrigation practices, weed control, mulching, earthing-up and cover cropping. Role of growth regulators, shade crops and shade regulation.
7.	Clove: Soil, climate and varieties, propagation-seed, vegetative and micro propagation systems and methods of planting, sowing spacing. Nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
8.	Nutmeg: Classification, soil, climate varieties, propagation-seed, vegetative and micro propagation systems and methods of planting, sowing spacing. Nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
9.	Cinnamon: Classification, soil and climate varieties, propagation-seed, vegetative and methods of planting spacing and sowing. Nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
10.	All spice: Classification, soil and climate varieties, propagation-seed, vegetative and micro propagation systems and methods of planting. Nutritional management, irrigation practices, weeds control, mulching. Training and pruning practices, role of growth regulators, shade crops and shade regulation.
11.	Curry leaf: soil and climate, varieties, propagation-seed and vegetative and methods of planting. Nutritional management, irrigation practices, weeds control, mulching.

	Training and pruning practices, role of growth regulators.
12.	Coriander: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
13.	Fenugreek: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
14.	Fennel: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
15.	Cumin: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
16.	Dill: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
17.	Celery: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
18.	Bishops weed: Soil, climate and varieties, seed sowing , spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators, shade crops and shade regulation.
19.	Saffron: Soil and climate varieties, propagation-seed, vegetative and micro propagation systems and methods of planting and spacing. Nutritional management, irrigation practices, weeds control, mulching and harvesting
20.	Vanilla: Soil and climate varieties, propagation-seed, vegetative and micro propagation systems and methods of planting sowing and spacing. Nutritional management, irrigation practices, weed control, mulching. Role of growth regulators.
21.	Thyme: Soil and climate varieties, propagation and methods of planting, and spacing. Nutritional management, irrigation practices, weeds control, mulching. Role of growth regulators.
22.	Rosemary: Soil and climate varieties, propagation and methods of planting and spacing. Nutritional management, irrigation practices, weeds control, mulching and cover cropping. Role of growth regulators.
23.	Harvesting, post-harvest technology, packaging, storage, value added products, methods of extraction of essential oil and oleoresins of Crops: Cardamom, Pepper, Betel vine, Ginger, Turmeric, Clove, Nutmeg, Cinnamon, All spice, Curry leaf, Coriander, Fenugreek, Fennel, Cumin, Dill, Celery, Bishops weed, Saffron, Vanilla, Thyme and Rosemary.
24.	Economics of cultivation, role of Spice Board and Pepper. Export Promotion Council, Institutions and Research Centers in R&D of Crops: Cardamom, Pepper, Betel Vine, Ginger, Turmeric, Clove, Nutmeg, Cinnamon, All Spice, Curry Leaf, Coriander, Fenugreek, Fennel, Cumin, Dill, Celery, Bishops Weed, Saffron, Vanilla, Thyme and Rosemary.

Topics in Practical:

S. No.	Topics
1.	Identification of varieties of spices and condiments.
2.	Propagation, seed treatment of spices and condiments.
3.	Sowing; layout, planting; hoeing and earthing up, manuring of spices and condiments.
4.	Use of weedicides, training and pruning in different spices and condiments.
5.	Maturity standards, harvesting, curing, processing, grading in spices and condiments.
6.	Extraction of essential oils and oleoresins form different spices and condiments.
7.	Visit to commercial plantations of spices and condiments.

Suggested Readings:

➢	Shanmugavelu, K.G. Kumar, N and Peter, K.V., 2005. Production technology of spices and plantation crops. . Agrosis, Jodhpur
➢	Shanmugavelu, K.G. and Madhava Rao, 1977. Spices and Plantation Crops. Madras Popular Book Depot.
➢	Kumar, N. J.B. M. Md. Abdul Khaddar, Ranga Swamy, P. and Irulappan, I., 1997. Introduction to Spices, Plantation Crops, and aromatic crops. Oxford & IBH, New Delhi.
➢	Pruthi, J.S., 1980. Spices and Condiments. Academic Press, New York.
➢	Pruthi, J.S., 1993. Major Spices of India- Crop Management Postharvest Technology. ICAR, New Delhi.
➢	Pruthi, J.S., 2001. Minor Spices and Condiments-Crop Management Post Harvest Technology. ICAR, New Delhi.
➢	Purseglove, Brown, E.G. Green, G.Z. Robbins, S.R.J. London, Longman, 1981. Spices Vol.I & II.

48. VSC – 315 (Breeding of Vegetable, Tuber and Spice Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Breeding objectives and important concepts of breeding, self-pollinated, cross pollinated and vegetative propagated crops
2.	Plant genetic resources, their conservation and utilization in crop improvement
3.	Breeding for insect resistance,
4.	Breeding for disease resistance
5.	Breeding for abiotic resistance
6.	Male sterility and self-incompatibility and their utilization in development of hybrids
7.	Origin, distribution of species, wild relatives and forms of Tomato
8.	Origin, distribution of species, wild relatives and forms of brinjal
9.	Origin, distribution of species, wild relatives and forms of Capsicum, Chilli

10.	Origin, distribution of species, wild relatives and forms of Cucurbits
11.	Origin, distribution of species, wild relatives and forms of Bhendi/okra
12.	Origin, distribution of species, wild relatives and forms of Cabbage and Cauliflower
13.	Origin, distribution of species, wild relatives and forms of tuber crops Potato sweet potato and cassava
14.	Origin, distribution of species, wild relatives and forms of Carrot, Radish
15.	Origin, distribution of species, wild relatives and forms of Spice crops Ginger, Turmeric and seed spices
16.	Breeding procedures for development of hybrids/varieties in various crops
17.	Genetic basis of adoptability and stability

Topics in Practical:

S. No.	Topics
1.	Floral biology and pollination mechanism in self- and cross-pollinated vegetables, tuber crops and spices,
2.	Working out phenotypic and genotypic heritability, genetic advance. GCA, SCA, combining ability, heterosis, heterobeltosis, standard heterosis, GxE interactions (stability analysis)
3.	Preparation and uses of chemical and physical mutagens.
4.	Polyploidy breeding and chromosomal studies.
5.	Techniques of F1 hybrid seed production
6.	Maintenance of breeding records

Suggested Readings:

- Hari Hara Ram, 2013.Vegetable Breeding: Principle and Practices**.** Kalyani Publishers.
- Ludhiana.
- Vishnu Swaroop, 2014. Vegetable Science &Technology in India. Kalyani Publishers.
- Ludhiana.
- Kallo.G, 1998. Vegetable Breeding (Vol. I to IV). CRC Press. Florida. 1988.
- H.P. Singh, 2009.Vegetable Varieties of India. Studium Press (India) Pvt Ltd. New Delhi.
- M.S. Dhaliwal. 2012. Techniques of Developing Hybrids in Vegetable Crops. Agrobios.
- Jodhpur.
- P.K.Singh, 2005. Hybrid Vegetable Development. CRC Press. Florida.
- M.S.Dhaliwal, 2009. Vegetable Seed Production & Hybrid Technology. Kalyani Publishers Ludhiana.

49. VSC – 316 (Potato and Tuber Crops)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Origin, area, production, economic importance and export potential of potato and tropical, sub-tropical and temperate tuber crops
2.	Description of varieties, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of potato
3.	Description of varieties, climate and soil requirement, season; propagation; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of sweet potato
4.	Description of varieties, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of arrow root
5.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of cassava
6.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of xanthosoma
7.	Description of varieties, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of colocasia
8.	Description of varieties, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of amorphophallus
9.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage,

	field and seed standards, marketing of dioscorea
10.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of Jerusalem artichoke
11.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of horse radish
12.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of yam bean
13.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of Chinese potato
14.	Description of varieties and hybrids, climate and soil requirement, season; seed rate; preparation of field; planting practices; spacing; water, nutrient and weed management; nutrient deficiencies. Use of chemicals and growth regulators; cropping systems, harvesting practices, yield; economic of cultivation. Post- harvest handling and storage, field and seed standards, marketing of winged bean

Topics in Practical:

S. No.	Topics
1.	Identification and description of potato and tropical, sup-tropical and temperate tuber crops
2.	Propagation of tuber crops
3.	Planting systems in tuber crops
4.	Field preparation and sowing/planting of tuber crops
5.	Top dressing of fertilizers in tuber crops
6.	Intercultural operations in tuber crops
7.	Use of herbicides and growth regulators in potato and tuber crops
8.	Identification of nutrient deficiencies, physiological disorders
9.	Harvest indices and maturity standards in potato and tuber crops
10.	Post-harvest handling, storage and marketing of potato and tuber crops
11.	Seed/planting material collection of different tuber crops
12.	Working out cost of cultivation of tuber crops

13.	Project preparation of commercial cultivation

Suggested Readings:

- S. Thamburaj. 2014. Text Book of Vegetable, Tuber Crops and Spices. ICAR, New Delhi.
- B.R. Choudhary 2009.AText Book on Production Technology of Vegetables. Kalyani Publishers. Ludhiana.
- T.K. Bose. 2002.Vegetable Crops. Nayaprakash. Kolkata
- P. Hazra. 2011. Modern Technology in Vegetable Production. New India Publishing Agency. New Delhi.
- T.R. Gopal Krishnan, 2007. Vegetable Crops. New India Publishing Agency. New Delhi.
- K.V. Kamath. 2007.Vegetable Crop Production. Oxford Book Company. Jaipur
- M.S. Dhaliwal, 2008.Handbook of Vegetable Crops. Kalyani Publishers. Ludhiana
- Singh, Umashankar, 2008. Indian Vegetables. Anmol Publications. Pvt.Ltd .New Delhi.
- K S Yawalkar, 2004.Vegetable Crops in India. Agri-Horticultural Pub. House. Nagpur.
- M.K. Rana, 2008.Olericulture in India. Kalyani Publishers. Ludhiana
- P. Hazra. 2006.Vegetable Science. Kalyani Publishers .Ludhiana
- Pratibha Sharma, 2007.Vegetables: Disease Diagnosis and Biomanagement. Avishkar Publishers. Jaipur
- Nath Prem. 1994.Vegetables for the Tropical Regions. ICAR New Delhi
- K.L.Chadha. 1993.Advances in Horticulture. Malhotra Publishing House. New Delhi
- Shanmugavelu, K.G. 1989. Production Technology of Vegetable Crops. Oxford and IBH publishing Co. Pvt. Ltd, New Delhi.
- Bose, T.K. 2003. Vegetable Crops. Naya udyog publishers, Kolkata. 2002. Naya Prakash, Calcutta.
- Prem Singh Arya, 1999. Vegetable Seed Production Principles. Kalyani Publishers, New Delhi.
- Choudhary, B., 1990. Vegetables. 8th edition. National Book Trust, New Delhi.
- Vincent Lebot, 2008.Tropical Roots and Tuber Crops. CAVI.
- J.E. Bradashaw, 2010. Root and Tuber Crops. Springer Publications.

50. VSC – 327 (Seed Production of Vegetable, Tuber and Spice Crops)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Introduction and history of seed industry in India
2.	Definition of seed, Classes-types of seed, differences between grain and seed
3.	Importance and scope of vegetable seed production in India
4.	Principles of vegetable seed production
5.	Factors affecting quality seed production, role of temperature, humidity and light in vegetable seed production

6.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of cole crops
7.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of root vegetables
8.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of solanaceous vegetables
9.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of cucurbits
10.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of okra
11.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of leafy vegetables and exotic vegetables
12.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of bulb crops
13.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of leguminous vegetables
14.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of spice crops like coriander, fennel and fenugreek etc.
15.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of tuber crops
16.	Land requirements, climate season, planting time, nursery management, seed rate, rouging, seed extraction and storage of exotic vegetables
17.	Seed production technology in turmeric and ginger
18.	Physiological and harvestable maturity for seed.
19.	Seed extraction and drying.
20.	Seed germination and Purity analysis.
21.	Field and seed standards.
22.	Seed legislation: seeds acts and rules.

Topics in Practical:

S. No.	Topics
1.	Studies of seed structure, colour, size, shape and texture
2.	Study on varietal characters, Identification of contaminants
3.	Field inspection of seed crops
4.	Harvesting and seed extraction: study of harvest indices, fruit grading and seed extraction techniques
5.	Seed sampling equipments, mixing and dividing methods
6.	Estimation of moisture
7.	Purity analysis – equipments used – reporting results

8.	Seed germination testing
9.	Tetrazolium test – evaluation
10.	Seed health test – testing and identification of pathogen /Insects
11.	Method of seed production in vegetable , tuber and spice crops
12.	Seed certification in vegetable , tuber and spice crops
13.	Seed processing machines
14.	Visit to seed production and processing units

Department – Social Science

51. EXT – 311 (Fundamentals of Extension Education)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history.
2.	Horticulture extension: process, principles and selected programmes of leading National and international forest institutes.
3.	People's participation in Horticulture programmes.
4.	Motivation of Farmers, rural youth and voluntary organizations for Horticulture extension work
5.	Rural Development: meaning, definition, objectives and genesis. Transfer of technology programmes like lab to land programme (LLP) national demonstration (ND), front line demonstration (FLD) Krishi Vigyan Kendras (KVK), Technology Assessment and Refinement Programme (TARP) etc. of ICAR
6.	Communication: meaning, definition, elements and selected models.
7.	Audio – visual aids: importance, classification and selection. Adoption and diffusion process
8.	Teaching and learning-concepts and principles, Teaching steps, Programming planning process – meaning, scope, principles and steps. Evaluation: meaning, importance and methods.
9.	Scope and importance of Participatory Rural Appraisal (PRA) & Rapid Rural Appraisal (RRA).
10.	Management and administration: meaning, definition, principles and functions. Concepts
11.	Human resource development (HRD), rural leadership. ICT in Extension education, ICT use in rural India.
12.	Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history.

Topics in Practical:

S. No.	Topics
1.	Visits to study structure, functions, linkages and extension programmes of ICFRE institutes.
2.	Voluntary organizations/Mahila Mandal, Village Panchayat, State Dept. of Horticulture /All India Radio (AIR).
3.	Exercises on distortion of message, script writing for farm broadcasts and telecasts.
4.	Planning, preparation & use of NPVA like poster, chart, flash cards, folders etc. and AVA.
5.	OHP & 35 mm slide projector transparencies. Identification of local leaders to study their role in extension work.

6.	Evaluation of some selected case studies of forestry extension programmes.
7.	Preparation of Village Agricultural productions plan.

Suggested Readings:

- Adivi Reddy, A., 2001, Extension Education, Sree Lakshmi press, Bapatla.
- Dahama, O. P. and Bhatnagar, O.P., 1998, Education and Communication for Development, Oxford and IBH publishing Co. Pvt. Ltd., New Delhi
- Jalihal, K. A. and Veerabhadraiah, V., 2007, Fundamentals of Extension Education and Management in Extension, Concept publishing company, New Delhi
- Muthaiah Manoraharan, P. and Arunachalam, R., Agricultural Extension, Himalaya Publishing House (Mumbai).
- Sagar Mondal and Ray, G. L., Text Book On Rural Development, Entrepreneurship And
- Communication Skills, Kalyani Publications
- Rathore, O. S. et al., 2012, Handbook of Extension Education, Agrotech Publishing Academy,Udaipur.
- Ray, G. L., 1991 (1st Edition), Extension Communication and Management, Kalyani Publishers,Ludhiana {7th revised edition - 2010}.
- Supe, S. V., 2013 (2nd Edition), A Text Book of Extension Education, Agrotech Publishing
- Academy, Udaipur
- Van Den Ban, A. W. and Hawkins, H. S., Agricultural Extension, S. K .Jain for CBS Publishers& Distributors, New Delhi.
- M. Hilaris. Indian Agriculture and Information: Soundari, New century Publications, 2011and communication technology (ICT)

52. AEC – 111 (Economics and Marketing)

Credit Hours: 3 (2+1)

Topics in Theory:

S. No.	Topics
1.	Theory: Nature and scope of economics, definition and concept, divisions of economics, economic systems, approaches to the study of economics.
2.	Consumption – theory of consumer behaviour, laws of consumption, classification of goods
3.	Wants – their characteristics and classification, utility and its measurement, cardinal and ordinal
4.	Law of diminishing marginal utility, law of equi -marginal utility, indifference curve and its properties, consumer equilibrium
5.	Theory of demand, demand schedule and curve market demand
6.	Price income and cross elasticizes, Engil's law of family expenditure – consumer's surplus, theory of firm, factors of production – land and its characteristics
7.	Labour and division of labour, theories of population. Capital and its characteristics –

	classification and capital formation
8.	Enterprises – forms of business organization – merits and demerits. Laws of return – law of diminishing marginal return – cost concepts. Law of supply – supply schedule and curve elasticities
9.	Market equilibrium distribution - theories of rent, wage, interest and profit.
10.	Price determination and forecasting under various market structures
11.	Marketing-definition – Marketing Process – need for marketing – role of marketing – Marketing functions – classification of markets – Marketing of various channels – Price spread – marketing Efficiency – Integration
12.	Constraints in marketing of agricultural produce. Market intelligence
13.	Basic guidelines for preparation of project reports – bank norms – Insurance – SWOT analysis Crises Management

Topics in Practical:

S. No.	Topics
1.	Techno-economic parameters for preparation of projects.
2.	Preparation of Bankable project for various agricultural products and its value added products
3.	Identification of marketing channels
4.	Calculation of price spread
5.	Identification of market structure
6.	Visit to different markets (Subjected to the availability of vehicle)

Suggested Readings:

- H L Ahuja. S. Chand and Company Limited. Advanced Economic Theory. Micro Economic Analysis.
- Chandra P. 1984. Projects: Preparation, Appraisal & Implementation. McGraw Hill Inc.
- Dewett, K.K. and Chand, A.1979. Modern Economic Theory. S.Chand and Co., New Delhi
- Dewett, K.K. and Varma, J.D. 1986. Elementary Economics. S.Chand and Co., New Delhi.
- Gupta RD & Lekhi RK. 1982. Elementary Economic Theory. Kalyani Publishers.
- Kotler Philip and Armstrong. Principles of Marketing. Prentice-Hall.
- Jhingan, M.L. 2012. Macro Economic Theory. Vrinda publishers, New Delhi .
- Kotler Philip and Armstrong. Principles of Marketing. Prentice-Hall.
- SS Acharya and N L Agarwal. 2005. Agricultural Marketing in India. Oxford and IBH Publishing Co. Pvt. Ltd
- Sampat Mukherjee. 2002. Modern Economic Theory. New Age International.
- Subba Reddy, S., Raghu ram, P., Neelakanta Sastry T.V., Bhavani Devi. I., 2010, Agricultural Economics, Oxford & IBH Publishing Co. Private Limited, New Delhi
- Willium J. Stanton. 1984. Fundamentals of Marketing. Tata McGraw-Hill Publication, New Delhi.
- C.N. Sontakki. Marketing Management. Kalyani Publishers, New Delhi.

- John Daniels, Lee Radebaugh, Brigham, Daniel Sullivan. International Business, 15th Ed., Pearson Education
- Aswathappa. International Business. Tata McGraw-Hill Education, New Delhi
- Fransis Cherunilam. International Business: Text and Cases, 5th Ed. PHI Learning, New Delhi.
- Prasanna Chandra. Projects. Tata McGraw-Hill Pu blication, New Delhi
- John M. Nicholas. Project Management for Business and Technology – Principles and Practices.
- Pearson Prentice Hall
- Harold Kerzner. Project Management – A System Approach to Planning, Scheduling, and Controlling. CBS Publishers & Distributors.
- Prasanna Chandra. Projects – Planning, Analysis, Selection, Financing, Implementation, and Review. Tata McGraw-Hill Publishing Company Ltd.
- P. Gopalakrishnan and V.E. Rama Moorthy. Textbook of Project Management. Macmillan.

53. AEC – 322 (Horti-Business Management)

Credit Hours: 2 (2+0)

Topics in Theory:

S. No.	Topics
1.	Farm management – definition, nature, characteristics and scope. Farm management principles and decision making,
2.	Production function, technical relationship, cost concepts, curves and functions- factors, product, relationship factors relationship, Product relationship
3.	Optimum conditions, principles of opportunity cost-equi-marginal returns and comparative advantages
4.	Time value of money, economics of scale, returns to scale, cost of cultivation and production
5.	Break even analysis, decision making under risk and uncertainly
6.	Farming systems and types. Planning – meaning, steps and methods of planning, types of plan, characteristics of effective plans
7.	Organization-forms of business organizations, organizational principles, division of labour
8.	Unity of command, scalar pattern
9.	Job design, span of control responsibility, power authority and accountability
10.	Direction – guiding, leading, motivating, supervising, coordination – meaning types and methods of controlling – evaluations, control systems and devices
11.	Budgeting as a tool for planning and control. Record keeping as a tool of control
12.	Functional areas of management – operations management – physical facilities, implementing the plan
13.	Scheduling the work, controlling production in terms of quantity and quality
14.	Materials management types of inventories, inventory cost.
15.	Managing the inventories, economic order quantity (EOQ)

16.	Personnel management – recruitment
17.	Selection and training job specialization. Marketing management
18.	Definitions, planning the marketing programmes
19.	Marketing mix and four P's of marketing. financial management – financial statement and rations
20.	Capital budgeting. Project management – project preparation evaluation measures

Suggested Readings:

- Heady Earl O and Herald R. Jenson,1954, Farm Management Economics. Prentice Hall, New Delhi
- S.S. Johl, J.R. Kapur ,2006, Fundamentals of Farm Business Management.
- Kalyani Publishers, New Delhi
- Karan Singh and Kahlon A S. Economics of Farm Management in India. Theory and Practice. New Delhi. Allied
- L.M. Prasad. 2001. Principles and Practices of Management, 9th Ed. S. Chand & Sons, New Delhi.
- Koontz Harold. Principles of Management. Tata McGraw-Hill Education Private Limited, New Delhi.
- P.C. Thomas. Managerial Economics, 9th Ed. Kalyani Publishers.
- K.K. Dewett and M.H. Navalur. Modern Economic Theory. S. Chand & Sons, New Delhi.
- P. Subba Rao. Human Resource Management. Himalaya Publications.
- S.P. Jain. Financial Accounting. Kalyani Publications, Ludhiana.
- Shapiro E. Macroeconomic analysis. Galgotia Publications Delhi
- Barry P J, Hopkins J A and Baker C B. Financial Management in Agriculture, 6th ed. Danville, IL Interstate Publishers.
- Gittiner, J P., Economic analysis of agricultural projects. The John Hopkins University Press Baltimore, USA, 1982
- Benjamin Mc Donald P 1985. Investment Projects in Agriculture- Principles and Case studies. Longman Group Limited. Essex. UK
- Pandey U K 1990. An Introduction to Agricultural Finance .Kalyani Publishers New Delhi

54. AEC – 323 (Entrepreneurship Development and Business Management)#

Credit Hours: 2 (1+ 1)

Topics in Theory:

S. No.	Topics
1.	Entrepreneurship Development: Assessing overall business environment in the Indian economy.
2.	Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. Globalization and the emerging business / entrepreneurial environment. Concept of entrepreneurship; entrepreneurial and managerial characteristics.
3.	Managing an enterprise; motivation and entrepreneurship development;
4.	Importance of planning, monitoring, evaluation and follow up, managing competition
5.	Entrepreneurship development programs; SWOT analysis, Generation, incubation and commercialization of ideas and innovations. Government schemes and incentives for promotion of entrepreneurship.
6.	Government policy on Small and Medium Enterprises (SMEs) / SSIs. Export and Import Policies relevant to horticulture sector. Venture capital. Contract farming and joint ventures,
7.	Public-private partnerships. Supply chain management and total quality management.
8.	Overview of horti inputs industry. Characteristics of Indian horticultural processing and export industry. Social Responsibility of Business. Communication Skills: meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills,
9.	Oral presentation skills developing organizational and managerial skills, problem solving skills. field diary and lab record; indexing, footnote and bibliographic procedures

Topics in Practical:

S. No.	Topics
1.	Listening and note taking, writing skills, oral presentation skills; field diary and lab record.
2.	Indexing, footnote and bibliographic procedures. Reading and comprehension of general.
3.	Technical articles, precis writing, summarizing, abstracting; Conducting market survey.
4.	Demand for product, preparing advertisements for popularization of product, news writing.
5.	Preparing project proposals, individual, group presentation, features of oral presentation.
6.	Presentation, evaluation of presentation and evaluation of sheet, dyadic communication-face to face conversation.
7.	Telephone conversation, rate of speech and clarity of voice, speaking and listening politeness, telephone etiquettes, organising general and group meeting, salient features of participation in seminars and conferences, conducting and participating in mock

	interviews

Suggested Readings:

- Benjamin MC Donald P. 1985, Investment Projects in Agriculture- Principles and Case studies. Longman Group Limited. Essex. UK
- Chole, R. R. et al., 2012, Entrepreneurship Development and Communication skills, Scientific publishers, Jodhpur
- Gittiner, J P., 1982, Economic Analysis of Agricultural Projects, The John Hopkins University Press Baltimore, USA
- Hopkins J A and Baker C B Danville, Financial Management in Agriculture, 6th ed Barry P J,IL Interstate Publishers
- Kotler Philip and Armstrong, Principles of Marketing. Prentice-Hall.
- Pandey U. K., An Introduction to Agricultural Finance
- Sagar Mondal and G. L. Ray, Text Book on Rural Development, Entrepreneurship and Communication Skills, Kalyani Publications
- Somani, L. L., Extension Education and Communication, Agrotech, Publishing Academy,Udaipur
- Dr.A.K.Singh,2009.Entrepreneurship Development and Management. Lakshmi Publications Ltd.,
- S. Anil Kumar, S.C Poornima, M.K. Abhraham and K. Jayashree, 2008; Entrepreneurship Development. New Age International Publishers

55. ENG – 111 (Communication Skills and Personality Development)

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	Introduction to Word Classes
2.	Introduction to Word Classes (Parts of Speech-I)
3.	Introduction to Word Classes (Parts of Speech-II)
4.	Structure of Verbs in English (Verbs Finite and Non-finite)
5.	Tenses
6.	Voice
7.	Sentence Patterns
8.	Conversations of Different Situations in everyday Life-I
9.	Conversations of Different Situations in Everyday Life-II
10.	Vowels and Consonants, Syllable
11.	Stress: Primary and Secondary
12.	Silent Letters and Classification of Words Intonation and Falling, Rising and Falling Rising Tone
13.	Reading and Comprehension of General and Technical Articles

14.	Precise Writing, Summarizing, Abstracting,
15.	Individual and Group Presentation, Impromptu Presentation, Public Speaking,
16.	Group Discussion, Organizing Seminars and Conferences

Topics in Practical:

S. No.	Topics
1.	Introduction to Word Classes
2.	Parts of Speech-I
3.	Parts of Speech-II
4.	Verbs Finite and Non-finite
5.	Tenses
6.	Voice
7.	Sentence Patterns
8.	Conversations of Different Situations in Everyday Life-I
9.	Conversations of Different Situations in Everyday Life-II
10.	Vowels and Consonants, Syllable
11.	Stress: Primary and Secondary
12.	Silent Letters and Classification of Words Intonation and Falling, Rising and Falling Rising Tone
13.	Reading and Comprehension of General and Technical Articles
14.	Precise Writing, Summarizing, Abstracting,
15.	Individual and Group Presentation, Impromptu Presentation, Public Speaking,
16.	Group Discussion, Organizing Seminars and Conferences

Suggested Readings:

- Balasubramanian T. 1989. A Text book of Phonetics for Indian Students. Orient Longman, New Delhi.
- Balasubrmanyam M. 1985. Business Communication. Vani Educational Books, New Delhi.
- Naterop, Jean, B. and Rod Revell. 1997. Telephoning in English. Cambridge University Press, Cambridge.
- Mohan Krishna and Meera Banerjee. 1990. Developing Communication Skills. Macmillan India Ltd. New Delhi.
- Krishnaswamy,. N and Sriraman, T. 1995. Current English for Colleges. Macmillan India Ltd. Madras.
- Narayanaswamy V R. 1979. Strengthen your writing. Orient Longman, New Delhi.
- Sharma R C and Krishna Mohan. 1978. Business Correspondence. Tata Mc Graw Hill publishing Company, New Delhi.
- Carnegie, Dale. 2012. How to Win Friends and Influence People in the Digital Age. Simon & Schuster.

- Covey Stephen R. 1989. The Seven Habits of Highly Successful People. Free Press.
- Spitzberg B, Barge K & Morreale, Sherwyn P. 2006. Human Communication: Motivation, Knowledge & Skills. Wordsworth.
- Verma, KC. 2013. The Art of Communication. Kalpaz.
- Dr. T. Bharati, Dr. M. Hariprasad and Pro. V. Prakasam, Personality Development and Communicative English. Neelkamal Publications Pvt. Ltd, New Delhi.
- Wren and Martin, S. Key to High School English Grammar and Composition- Chand and Company Ltd., New Delhi
- Wren and Martin, S. High School English Grammar and Composition- Chand and Company Ltd., New Delhi
- Raymond Murphy, English Grammar in Use. Cambridge University Press
- The Official Guide to the TOEFL Test-IV Edition, Educational Testing Services. Mc Graw Hill, New Delhi.
- Balasubramanyam ,M .1985.Business communication. Vani Educational Books Ansariroad,New Delhi.
- KrishnaMohanandMeeraBanerjee1990.DevelopingCommunicationSkills.

56. STAT – 122 (Information and Communication Technology)*

Credit Hours: 2 (1+1)

Topics in Theory:

S. No.	Topics
1.	IT and its importance
2.	IT tools
3.	IT-enabled services and their impact on society
4.	Computer fundamentals
5.	Hardware and software
6.	Input and output devices
7.	Word and character representation; features of machine language
8.	Assembly language, high-level language and their advantages and disadvantages
9.	Principles of programming- algorithms and flowcharts
10.	Operating systems (OS) - definition, basic concepts, introduction to WINDOWS and LINUX Operating Systems
11.	Local area network (LAN), Wide area network (WAN), Internet and World Wide Web, HTML and IP
12.	Introduction to MS Office - Word, Excel, Power Point
13.	Audio visual aids - definition, advantages, classification and choice of A.V aids
14.	Cone of experience and criteria for selection and evaluation of AV aids
15.	Video conferencing. Communication process, Berlo's model, feedback and barriers to communication

Topics in Practical:

S. No.	Topics
1.	Exercises on binary number system
2.	Discussion about algorithm and flow chart preparation Techniques
3.	Practice session in MS Word
4.	Practice session in MS Excel
5.	Practice session in MS Power Point
6.	Internet applications
7.	Creation and operation of email account
8.	How to perform Web Browsing
9.	Practice on Analysis of data using MS Excel
10.	How to use & Handle audio visual equipments
11.	Planning, preparation, presentation of posters & charts
12.	Use overhead projector, transparencies and slides
13.	Organization of an audio-visual programme

Suggested Readings:

- Gurvinder Singh, Rachhpal Singh & Saluja KK. 2003. Fundamentals of Computer Programming and Information Technology. Kalyani Publishers.
- Harshawardhan P. Bal. 2003. Perl Programming for Bioinformatics. Tata McGraw-Hill Education.
- Kumar A 2015. Computer Basics with Office Automation. IK International Publishing House Pvt Ltd.
- Rajaraman V & Adabala N. 2015. Fundamentals of Computers. PHI.

57. PHE – 211 (Physical and Health Education)

Credit Hours: 1 (0+1) (NC*)

Topics in Theory:

S. No.	Topics
1.	Introduction to physical education.
2.	Posture, exercise for good posture, physical fitness exercises for agility, strength, coordination, endurance and speed.
3.	Assignments about the Rules/ regulations of important games
4.	Skill development in any one of the games – football, cricket, volleyball, badminton.
5.	Rules and regulations of athletic events
6.	Encourage students to participate in – shuttle badminton, chess and table tennis and provide coaching.
7.	Encourage students to participate in – broad jump, high jump, triple jump, javelin throw,

NON-GRADIAL COURSES

Semester I

Course Title: National Service Scheme I 2(0+2)

- **Introduction and basic components of NSS:**
- **Orientation**: history, objectives, principles, symbol, badge; regular programmes under NSS, organizational structure of NSS, code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health
- **NSS programmes and activities**
- Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth programme/ schemes of GOI, coordination with different agencies and maintenance of diary
- **Understanding youth**
- Definition, profile, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change
- **Community mobilisation**
- Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilisation involving youth-adult partnership
- **Social harmony and national integration**
- Indian history and culture, role of youth in nation building, conflict resolution and peace-building
- **Volunteerism and shramdan**
- Indian tradition of volunteerism, its need, importance, motivation and constraints; shramdan as part of volunteerism
- **Citizenship, constitution and human rights**
- Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information
- **Family and society**
- Concept of family, community (PRIs and other community-based organisations) and society
- **Importance and role of youth leadership**
- Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership
- **Life competencies**
- Definition and importance of life competencies, problem-solving and decision-making, inter personal communication

- **Youth development programmes**
- Development of youth programmes and policy at the national level, state level and voluntary sector; youth-focused and youth-led organisations
- **Health, hygiene and sanitation**
- Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programmes and reproductive health.
- **Youth health, lifestyle, HIV AIDS and first aid**
- Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid
- **Youth and yoga**
- History, philosophy, concept, myths and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method
- **Vocational skill development**
- To enhance the employment potential and to set up small business enterprises skills of volunteers, a list of 12 to 15 vocational skills will be drawn up based on the local conditions and opportunities. Each volunteer will have the option to select two skill-areas out of this list
- **Issues related environment**
- Environmental conservation, enrichment and sustainability, climatic change, natural resource management (rain water harvesting, energy conservation, forestation, waste land development and soil conservation) and waste management
- **Disaster management**
- Introduction and classification of disaster, rehabilitation and management after disaster; role of NSS volunteers in disaster management.
- **Entrepreneurship development**
- Definition, meaning and quality of entrepreneur; steps in opening of an enterprise and role of financial and support service institution.
- **Formulation of production-oriented project**
- Planning, implementation, management and impact assessment of project
- **Documentation and data reporting**
- Collection and analysis of data, documentation and dissemination of project reports
- **Youth and crime**
- Sociological and psychological factors influencing youth crime, cyber-crime, pear mentoring in preventing crime and awareness for juvenile justice
- **Civil/self defence**

- Civil defence services, aims and objectives of civil defence; needs and training of self-defence
- **Resource mobilisation**
- Writing a project proposal of self-fund units (SFUs) and its establishment
- **Additional life skills**
- Positive thinking, self-confidence and esteem, setting life goals and working to achieve them, management of stress including time management.

Semester I

Course Title : National Cadet Corps **2(0+2)**

- Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- Sizing, numbering, forming in three ranks, open and close order march and dressing.
- Saluting at the halt, getting on parade, dismissing and falling out.
- Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear.
- Turning on the march and wheeling. Saluting on the march.
- Marking time, forward march and halt.
- Changing step, formation of squad and squad drill.
- Command and control, organization, badges of rank, honours and awards
- Nation Building- cultural heritage, religions, traditions and customs of India. National integration.
- Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizen.
- Leadership traits, types of leadership. Character/personality development.
- Civil defence organization, types of emergencies, firefighting, protection,
- Maintenance of essential services, disaster management, aid during development projects. 15. Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning.
- Structure and function of human body, diet and exercise, hygiene and sanitation.
- Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health.
- Adventure activities
- Basic principles of ecology, environmental conservation, pollution and its control.

STUDENT READY

Rural Entrepreneurship Awareness Development Yojana

Student READY

Rural Entrepreneurship
Awareness Development Yojana

भाकृअनुप
ICAR

कृषि शिक्षा विभाग
AGRICULTURAL EDUCATION DIVISION
भारतीय कृषि अनुसंधान परिषद
Indian Council of Agricultural Research
कृषि अनुसंधान भवन-II, नई दिल्ली - 110 012
Krishi Anusandhan Bhawan-II, New Delhi - 110 012

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Agricultural Education Division
Indian Council of Agricultural Research, New Delhi

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PREFACE

Student READY (Rural Entrepreneurship Awareness Development Yojana) programme is a new initiative of Indian Council of Agricultural Research to reorient graduates of Agriculture and allied subjects for ensuring and assuring employability and develop entrepreneurs for emerging knowledge intensive agriculture. This envisages the introduction of the programme in all the Agricultural Universities as an essential prerequisite for the award of degree to ensure hands on experience and practical training depending on the requirements of respective discipline and local demands. This programme includes five components i.e. Experiential Learning, Rural Awareness Works Experience, In-Plant Training / Industrial attachment, Hands-on training (HOT) / Skill development training and Students Projects. All these components are interactive and are conceptualized for building skills in project development and execution, decision-making, individual and team coordination, approach to problem solving, accounting, quality control, marketing and resolving conflicts, etc. with end to end approach.

Experiential Learning (EL) helps the student to develop competence, capability, capacity building, acquiring skills, expertise and confidence to start their own enterprise and turn *"Job Creators instead of Job Seekers"*. This is a step towards *"Earn while Learn"* concept. The Rural Awareness Works Experience (RAWE) helps the students primarily to understand the rural situations, status of technologies adopted by farmers, prioritize the farmers problems and to develop skills and attitude of working with farm families for overall development in rural area.

Technology and globalization are ushering an era of unprecedented change. The need and pressure for change and innovation is immense. To enrich the practical knowledge of the students, in-plant training shall be mandatory. Hands-on training aims to make conditions as realistic as possible. The biggest benefit of hands-on training is the opportunity for repeated practice. Student project work provides several opportunities to students to learn several aspects that cannot be taught in a class room or laboratory. In order to provide such opportunities to the graduates of agricultural science, students project is proposed as one of the components of the Student READY.

I am sure this programme will be very useful and beneficial to the students/ graduates in gaining the competence for entrepreneurship, in building confidence, skill and acquire Indigenous Technical Knowledge (ITK) of the locality and thereby, preparing the pass-out graduates for self-employment and will play the key role in overall personality development.

I believe that our efforts will help in improvement of the Agriculture Education System and sustainable development in the country.

October, 2016
New Delhi

N.S. Rathore
Deputy Director General
Agricultural Education Division, ICAR

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STUDENT READY: AN OVERVIEW

Introduction

The Indian Council of Agricultural Research (ICAR) is an autonomous organisation under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare, Government of India and the largest National Agricultural Research and Education System (NARES) in the world. The ICAR is the apex body for coordinating, guiding and managing research and education in agriculture in the entire country through the Agricultural Education Division. The Agricultural Education Division, ICAR undertakes planning, development, coordination, human resource development and educational quality reforms in higher agricultural education in the country and, thus, strives for maintaining and upgrading quality and relevance of higher agricultural education through partnership and efforts of the ICAR-Agricultural Universities (AUs) system comprising State Agricultural Universities (SAUs), Deemed to be Universities (DUs), Central Agricultural Universities (CAUs) and Central Universities (CUs) with Agriculture Faculty.

About Student READY

The Student READY (Rural Entrepreneurship Awareness Development Yojana) programme aims to provide rural entrepreneurship awareness, practical experience in real-life situation in rural agriculture and creating awareness to undergraduate students about practical agriculture and allied sciences. The programme will help in building confidence, skill and acquire Indigenous Technical Knowledge (ITK) of the locality and thereby,

preparing the pass-out for self-employment. It also aims to provide opportunities to acquire hands-on-experience and entrepreneurial skills. To reorient graduates of agriculture and allied subjects for ensuring and assuring employability and develop entrepreneurs for emerging knowledge intensive agriculture, it was felt necessary to introduce this program in all the AU's as an essential prerequisite for the award of degree to ensure hands on experience and practical training.

The Fifth Deans committee has given detailed curriculum of student READY programme for all the disciplines in agriculture and allied sciences. The course curricula have been restructured to develop much needed skills and entrepreneurial mind-set among the graduates to take up self-employment, contribute to enhanced rural livelihood and food security, sustainability of agriculture and be propeller for agricultural transformation. The following components are proposed for carrying out one year Student READY programme in all the Under graduate (UG) disciplines:

- Experiential Learning on Business Model / Hands on Training
- Experiential Learning on Skill Development
- Rural Awareness Works Experience (RAWE)
- Internship / In-Plant Training / Industrial attachment
- Students Projects

The students will be required to have any three of the five components listed above depending on the requirement of their graduate education but it should be implemented for one complete year, so that their education up to level of III year may get right information and in the IV year and finally they should attain right stage of entrepreneurship. In some disciplines where some components, for eg., Experiential Learning is not possible at graduate level, the students will be given Hands on Training and/or Skill Development Training, but it should be (out of these 5 components) implemented for the complete year. All the above mentioned components are interactive and are conceptualized for building skills in project development and execution, decision-making, individual and team coordination, approach to problem solving, accounting, quality control, marketing and resolving conflicts, etc. with end to end approach.

- Experiential Learning is an opportunity for the students to develop high quality professional competence, skill development and confidence to start their own enterprise. This is a step towards *"Earn while learn"*. Experiential Learning aims towards Practical Work Experience in Real Life Situation among the undergraduate students and therefore it helps student become *"Job Providers rather than Job Seekers"*.
- Rural Awareness Works Experience enable the students to gain rural experience, give them confidence and enhance on farm problem solving abilities in real life situations, especially in contact with farmers, growers, etc.
- In-plant training of short duration in relevant industry is useful to gain the knowledge and experience of the work culture. In Plant training in reputed organization / MNC's/ other organised sectors provides an industrial exposure to the students for developing their career in the Agro based industries.
- Skill development component includes use of Agriculture Systems and devices for enhancing functional skills. It is expected that basic infrastructure and Experiential Learning Units in the university will help in boosting livelihood ensuring opportunities among the Agricultural graduates.

- Student Project is essential for students who are interested in higher education. Through this they will gain expertise for identification of research problem, planning and setting up experiments and writing of reports, etc.
- In the disciplines of Dairy Technology, Food Technology and Agricultural Engineering, there will be in-plant training in place of RAWE. The students of Veterinary Science discipline will undergo internship training at hospitals.

All the components as per suitability of course i.e. Experiential Learning, Skill Development Training, Rural Awareness Work Experience (RAWE), Internship/ in-plant training and Student Projects are included in the final year of study for 2 semesters to provide entrepreneurial skills, confidence and hands on experience. There are 20 credits for Experiential Learning/ Skill Development Training, 10 credits for RAWE and 10 Credits for Industry Attachment/Student Project. For Veterinary Science students, Experiential Learning is designed as per VCI pattern.

Some of the important components of Student READY programme are as under:

Experiential Learning (EL)

The word 'experiential' essentially means that learning and development are achieved through personally determined experience and involvement, rather than on received teaching or training, typically in group, by observation, study of theory or hypothesis,

bring in innovation or transfer of skills or knowledge. Experiential learning is a business curriculum-related endeavour which is interactive. EL is for building (or reinforcing) skills in project development and execution, decision-making, individual and team coordination, approach to problem solving, accounting, marketing and resolving conflicts, etc. The programme has end to end approach. Carefully calibrated activities help the participants to explore and discover their own potential and both activities and facilitation play a critical role in enhancing team performance.

EL provides the students an excellent opportunity to develop analytical and entrepreneurial skills and knowledge through meaningful hands on experience, confidence in their ability to design and execute project work. The main objectives of EL are:

- To promote professional skills and knowledge through hands on experience.
- To build confidence and ability to work in project mode.
- To acquire enterprise management capabilities.

The experiential learning programme will be offered for 180 days (one semester) period in the final year. As the programme is enterprise oriented, students and faculty are expected to attend the activities of the enterprise even on institutional holidays with total commitment, and without any time limit or restriction of working hours for ELP. The Experiential Learning Programme shall be run for full year by making two groups and rotating activities of the final year in two groups.

Rural Awareness Works Experience

The Rural Awareness Works Experience (RAWE) helps the students primarily to understand the rural situations, status of agricultural technologies adopted by farmers, prioritize the farmer's problems and to develop skills and attitude of working with farm families for overall development in rural area. The timings for RAWE can be flexible for specific regions to coincide with the main cropping season.

The main objectives of RAWE are:

- To provide opportunity to the students to understand the rural situation in relation to agriculture and allied activities.
- To make the students familiar with socio-economic conditions of the farmers and their problems.
- To impart diagnostic and remedial knowledge to the students relevant to real field situations through practical training.
- To develop effective communication skills of students with farmers using latest extension methodologies in transfer of technology.
- To develop confidence and competence among students to solve complex agricultural problems.
- To acquaint students with on-going extension and rural development programmes.

In-Plant Training (IPT)

Technology and globalization are ushering an era of unprecedented change. To augment this, the need and pressure for change and innovation is inevitable. To enrich the practical knowledge of the students, in-plant training shall be mandatory in the last semester for a period of up to 10 weeks. In this training, students will have to study a problem in industrial perspective and submit the reports to the university. Such in-plant trainings will provide an industrial exposure to the students as well as to develop their career in the high tech industrial requirements. In-Plant training

is meant to correlate theory and actual practices in the industries. It is expected that sense of running an industry may be articulated in a right way through this type of industrial attachment mode. The major objectives of In Plant Training (IPT) are:

- To expose the students to industrial environment.
- To familiarize the students with various Materials, Machines, Processes, Products and their applications along with relevant aspects of shop management.
- To make the students understand the psychology of the workers and approach towards problems and practices followed in industries.
- To make the students understand the scope, functions and job responsibilityin various departments of an organization.
- Exposure to various aspects of entrepreneurship during the programme period.

Course curriculum: The Fifth Deans Committee has recommended the following discipline-wise syllabus for Student READY programmes. VCI guidelines are followed in Veterinary Sciences.

I. AGRICULTURE

Semester VII

Rural Awareness Works Experience (RAWE) and Agro-Industrial Attachment (AIA)

This programme will be undertaken by the students during the VII semester for a total duration of 20 weeks with a weightage of 0+20 credit hours in two parts viz., RAWE and AIA. It will consist of general orientation and on campus training by different faculties followed by village attachment/unit attachment in University/ College/ KVK or a Research station. The students will be attached with the agro-industries to get an experience of the industrial environment and working. Weightage in terms of credit hours will be given depending upon the duration of stay of students in villages/agro-industries. At the end of RAWE/AIA, the students will be given one week for project report preparation, presentation and evaluation. The students would be required to record their observations in field and agro-industries on daily basis and will prepare their project report based on these observations.

Semester VIII

Experiential Learning Programme (ELP)/ Hands on Training (HOT)

This programme will be undertaken by the students preferably during the VIII semester for a total duration of 24 weeks with a weightage of **0+20** credit hours. The students will register for any of two modules, of (**0+10** credit hours each) listed below:

- Production Technology for Bio-agents and Bio-fertilizers
- Seed Production and Technology
- Mushroom Cultivation Technology
- Soil, plant, water and seed Testing
- Poultry Production Technology
- Hybrid Seed Production Technologies
- Floriculture and Landscaping
- Food Processing
- Commercial Horticulture
- Agriculture Waste Management
- Organic Production Technology
- Commercial Sericulture

In addition to these ELP modules, other important modules may be given to the students by SAUs. Indian Council of Agricultural Research has already provided financial help for establishment of two or more Experiential Learning units in each State Agricultural University and the universities to plan accordingly.

II. AGRICULTURAL ENGINEERING

Student READY programme of the Agricultural Engineering is proposed to have the following components:

In summer break after semester IV

Student READY Skill Development Training - I for five weeks with a credit load of **0+5** credit hours.

In the summer break after semester VI

Student READY Skill Development Training -II for five weeks with a credit load of **0+5** credit hours.

Semester VII

Industrial attachment of 10 weeks with a credit load of **0+10** credit hours. On campus Experiential Learning Programme of 12 weeks with a credit load of **0+10** credit hours.

Semester VIII

Project Planning and Report Writing of 12 weeks during with a weightage of **0+10** credit hours.

III. BIOTECHNOLOGY

The Student READY programme for Biotechnology will comprise of following three parts:

Semester VII

- Any one of the following four modules for in-house skill development with a duration of 20 weeks carrying a weightage of **0+20** credit hours to be taken up during VII semester.
  a. Plant Biotechnology
  b. Animal Biotechnology
  c. Microbial and Environmental Biotechnology
  d. Bioinformatics

Semester VIII

- Project formulation, execution and presentation of 12 weeks duration to be taken up during VIII semester with a weightage of **0+10** credit hours.
- Entrepreneurial Development in Biotechnology (On-campus/Off campus) of 12 weeks duration to be taken up during VIII semester in Micro-propagation; DNA fingerprinting; Genetic purity for maintenance breeding; Marker assisted selection; Haploid production; Database Management skills; Molecular Diagnostics; Recombinant protein production; Animal cell culture and maintenance; Fermentation, Biopharma production; Bioprocess enrichment; Bioremediation; Bio-fules, etc. with a weightage of **0+10** credit hours.

IV. DAIRY TECHNOLOGY

Rural Dairy Work Experience Programme-I (Summer Break after II semester) of 5 weeks with a credit load of **0+5** credit hours to provide exposure in the areas on Milk Production & Procurement to be taken up in State Dairy Federations/ Dairy Development Departments/ Private Dairies/ Animal Husbandry Department/ Cattle farm/ Progressive dairy farmers.

Rural Dairy Work Experience Programme-II (Summer Break after IV semester) of 5 weeks with a credit load of 0+5 credit hours for exposure on Preliminary Dairy Operations to be taken up in Experimental Dairy/ Referral lab/ Dairy Plants/ Product manufacturing operations in Dairy & Food Industry.

Semester VII

In-Plant Training in VII Semester of 24 weeks with a credit load of **0+20** credit hours. Plant visits and involvement in processing and manufacturing of value added products in each Dairy Technology course to have Industrial exposure in specialized products like Market Milk, Ice Cream, Milk Powders, Cheese, By-products etc. should be made compulsory.

Semester VIII

Experiential Learning Module of 10 weeks with a credit load of **0+10** credit hours. The module will run concurrently in the final semester along with the regular courses. This shall include development of Detailed Project Report on setting up of enterprise in the selected areas of product manufacture and Evaluation of the Module.

V. FISHERIES

Student READY Programme will be taken up during VII and VIII semesters and will have the following components:

Semester VII

- Student READY-In-plant attachment for 12 weeks (0+10 credit hours).
- Student READY- Rural Fisheries Work Experience Programme for 8 weeks(0+8 credit hours).
- Student READY- Study Tour (in and outside State) for 4 weeks (0+2 credit hours).

Semester VIII

Student READY Experiential Module

This will include capacity building and skill development of the students in planning, development, formulation, monitoring and evaluation of project for entrepreneurial proficiency with a total credit load of 0+20 credit hours as detailed below:

Skill Development will have 0+5 credit hours and include Aquarium fabrication, Analysis of soil and water quality parameters, Preparation of Fish products or in any appropriate applied aspect of fisheries.

Experiential Learning Program will have 0+12 credit hours' a minimum of two out of the following areas should be decided by each university:

- Ornamental fish culture
- Seed Production
- Trade and export management
- Aqua-clinic
- Post-Harvest Technology
- Aqua farming

Students Project: Students may select relevant or interested area of specialization such as Fish pathology, Fish diagnosis, Fish pharmacology, Fish Toxicology, Fish nutrition, Fish immunology, Fish genetics and breeding, Ornamental fish production, Genomics in Aquaculture, Fish stock assessment, Aquatic pollution, Fish value addition, Fish nutrition, Fish processing waste management, Quality control and quality assurance, Fish products and by-products etc. The student will prepare a research project plan and it will be presented in front of committee appointed by the Dean of the respective college. Each student will be provided with one advisor, who will guide the student in completion of proposed research plan. A total of 3 credit hours will be allotted for preparation of the project and its presentation as a seminar. They will be exposed with identifications of problems in experimental setup and project preparation.

VI. FOOD TECHNOLOGY

Student READY programme will be taken up during semesters VII and VIII and will have the following components:

Semester VII

- **Student READY - Experiential Learning** with a credit load of 0+14 credit hours through relevant pilot plants for processing of various commodities, preferably on campus. This shall include development of detailed project report on setting up of enterprise in the selected areas of product manufacture and evaluation of the module. The experiential learning is intended to build practical skills and entrepreneurship attributes among the students with an aim to deal with work situations and for better employability and self-employment.

- **Student READY -** Project with a credit load of 0+3 credit hours: to undertake investigation of selected problems of special interest in Food Processing Technology. The work includes library work, field or laboratory research, recording data, analysing data and writing of report, etc.
- **Student READY -** Seminar including preparation of synopsis, presentation and discussion by each student on current topics / interests in Food Processing technology with a weightage of 0+1 credit hours.

Semester VIII

- Student READY - Educational Tour of two- three weeks to various industries within and outside the state of the University and submission of report on Industrial Tour carrying a weightage of 0+2 credit hours.
- **Student READY - In-plant training** of one semester duration with a credit load of 0+20 credit hours at relevant food processing industry, machinery manufacturer, marketing or other agencies. The in-plant training is intended to expose the students to an environment in which they are expected to be associated in their future career. The students will be required to have hands-on-experience in one or more commercial establishment.

VII. FORESTRY

Semester V

Student READY Experiential Learning Module - I (5 weeks) (0+5 credit hours). Any one of the modules to be taken up during Semester V:

- Production and Marketing of high value Forest Produce (FPU)
- Raising Quality Planting Materials for Forest Regeneration (SAF/FBT)
- Apiculture/Sericulture (FBU/NRM/WLS)
- Ecotourism (BSS/WLS)
- Wild Animal Health Management– WLS

Semester VI

Student READY Experiential Learning Module – II (5 weeks) (0+5 credit hours). Any one of the modules to be taken up during semester VI:

- Production and Marketing of high value forest produce (FPU)
- Raising Quality Planting Materials for forest regeneration (SAF/FBT)
- Apiculture/Sericulture (FBT/NRM/WLS)
- Ecotourism (BSS/WLS)
- Wild Animal Health Management – WLS

Semester VII

Student READY Forestry Work Experience (FOWE) 24 weeks will be taken up in semester VII with a credit load of 0+20 credit hours. The programme will have the following components:

- Orientation
- Forest Range Training Programme
- Industrial Placement
- Weapon Training and First-Aid Training
- Socio-economic Surveys and Village Attachment
- Socio-economic Surveys and Village Attachment
- Report Writing and Presentations

Semester VIII

Student READY Project Work & Dissertation 10 weeks (0+10 credit hours) to be taken up during the semester VIII.

VIII. HOME SCIENCE

A) B.Sc (Hons) Community Science

The Student READY programme will be taken up during VII and VIII semesters. The program will be divided into two parts:

Semester VII

Student READY Experiential Learning Programme: the students will take up any one of the following ELP modules for a period of 24 weeks with a credit load of 0+20 credit hours during the VII semester.

Module 1: Product Development and Entrepreneurship

This module aims to grant practical knowledge to students regarding product development and entrepreneurship, covering all aspects related to income generation through production and sale of clothing and textiles, and interior decoration products and also the management of their entrepreneurial ventures. The students will take up the work on the topics like:

- Apparel Designing Technique-Flat Pattern and Draping
- Principles of Textile Designing
- Fashion Illustrations
- Computer Aided Designing-Pattern Designing
- Retailing and Merchandising- Textiles and Apparel
- Instructional Video Production
- Public Relations and Social Marketing
- Event Management
- Interior Design and Decoration
- Computer Aided Interior Designing
- Tourism and Hospitality Management
- Web Designing and Multimedia Production

Module 2: Community Nutrition and Welfare

This module aims to impart practical knowledge to students regarding community welfare encompassing all the aspects viz. diet counselling, food preservation, food service and hospitality management, nutraceuticals and health foods, early childhood care, education and counselling for parents/ community, multimedia and video production. Students would be ready to conduct and manage community welfare programs independently. The students will take up the work on topics like:

- Print and Electronic Journalism
- Web Designing and Multimedia Production Marketing
- Instructional Video Production
- Diet and Nutrition Counselling
- Food Preservation and Storage
- Food Service and Hospitality Management
- Nutraceuticals and Health Foods
- Methods and Materials for Teaching Young Children
- Education and Counselling for Parents and Community
- Early Childhood Care, Education and Management
- Developmental Assessment of Young Children

Semester VIII

Student READY In-plant training / Internship / RAWE will be taken up during semester VIII for a period of 20 weeks with a credit load of 0+20 credit hours.

B) B.Sc. (Hons) Food Nutrition and Dietetics

The Student READY programme will be taken up during VII and VIII semesters. The programme will be divided into two parts:

Semester VII

Student READY - In-plant Training: Students will be deputed to nearby Hospitals, Testing labs and Processing units/Foods Industries for a period of 20 weeks during the semester VII with a credit load of 20 credit hours. The students will be provided a platform to study at least two topics in depth depending upon place of their training . At the end of the training they will make a presentation before faculty and other students.

Semester VIII

Student READY Hands-on-training: The students will take up Hands-on-training programme for a period of 24 weeks with a 20 credit hours during the VIII semester. The following aspects will be taken up during the training to develop competence, capability, capacity building, acquiring skills, expertise and confidence to start their own enterprise.

- Fruits and Vegetables: Preparation and Utilization
- Nutritional Status Assessment Methods
- Food Service Management
- Diet and Nutrition Counselling
- Special Project depending upon the regional requirement
- Entrepreneurship Development and Business Management

IX. HORTICULTURE

Student READY Experiential Learning (Professional Package) will be for the duration of 20 weeks and Student READY Programme will be taken up during semesters VII and VIII and will have the following components:

Semester VII & VIII

Student READY- Rural Horticulture Works Experience (RHWE) and Placement in Industries. This programme will be taken up during the VII semester for duration of 24 weeks and will be allotted 0+20 credit hours. The programme will include orientation, village stay, all India study tour, industrial placement programme, report writing and final examination will carry a weightage of 0+20 credit hours. Students can select any two modules from the following depending on the facilities available at the college:

- Commercial horticulture
- Protected cultivation of high value Horticulture crops
- Processing of fruits and vegetables for value addition
- Floriculture and landscape architecture
- Bio-inputs: Bio-fertilizers and bio-pesticides
- Mass multiplication of plant and molecules through tissue culture
- Mushroom culture
- Bee keeping

X. SERICULTURE

The Student READY programme will be implemented during Semester VII and VIII with the following components:

Semester VII

Student READY - Experiential Learning program (ELP)/ Hands on Training (HOT) modules - the programme will be taken up in VII semester for a period of 20 weeks carrying a weightage of 0+20 credit hours. The students can take up one of the following modules:

- Host Plant Production
- Cocoon Crop Production
- Silk Product Science
- Natural Resource Management

Semester VIII

Student READY - Rural Works Experience Programme (Sericulture) will be taken up during semester VIII for a period of 24 weeks and a credit load of 20 credit hours. The students will have exposure to Placement in Grainage Technology, Seri Clinic, Placement in Silk Product Technology, Placement in Value Addition to Sericulture By-Products and Practical Extension Work in Villages.

Evaluation

- Students shall be evaluated component-wise under village attachment/ agro-industrial attachment/ hands on training/ skill development training/experiential learning/student projects.
- Each College of the University will designate a Student READY Programme Coordinator and component wise evaluation committees. These committees shall evaluate the activities and progress for the component undertaken, giving due weightage to the observations made by the Scientists/Agro-industrial Officer and the Programme Coordinator with whom they are attached.
- The Credit Hours allotted to the Student READY program are as per the components, so the minimum condition of attendance and grading system will apply.
- It is expected that at the end of Student READY programme, the students should gain competency for entrepreneurship, which should be innovative and creative in nature. The evaluation committee must ensure percentage increase in this competency at the end and successful organization of the Student READY programme in various disciplines.
- The subsequent sections provide detailed information of each component.

EXPERIENTIAL LEARNING IN AGRICULTURAL AND ALLIED SCIENCE

The Experiential Learning and Hands-on training programme with business mode or without business mode as for skill development on Agricultural, Horticulture and other branches may be established at different College of State Agriculture University with a view to provide entrepreneurship skills among graduating students in the relevant field of Agricultural Sciences or its allied branches. In order to fulfill the requirement, various systems based on Agriculture may be installed which include different sub sectors of Agriculture. Through this facility, students will receive hands-on training on production of value added products based on Agriculture, Horticulture etc. and repair and maintenance of different systems and devices etc. Training may also be given on modern area of agriculture and raising of production quality & quality wise for getting more return through enhanced agricultural production.

Objectives

- To promote employment opportunities and entrepreneurship developmental skills in the field of agriculture science through integration of basic knowledge and conceptual aspects with experiential learning in specialized field of use of value added technology, devices & system.
- To generate trained skill man power for self-employment and entrepreneurship development.
- To earn through value addition technologies available locally through integration of integrated farming, food safety, agriculture market and good agriculture practices.
- To explore wider opportunities an integration of different agriculture on farm practices & devices for revenue generation.
- To integrate education with enterprenenship for employment generation so that Agriculture students may become job providers rather than job seekers.

Activities Envisaged

- To conduct hands-on training and entrepreneurship skills among outgoing UG students interested in the field of Agriculture & allied branches.
- To conduct special training in frontier areas of Agriculture for undergraduate degree students for establishing an enterprise and its management.
- To explore possibility of expanding scope/ federating students into business group and for industrial sectors.

This would impart skills among students in preparation of project feasibility and implementation reports for establishment of production units, procurement of raw materials, production of value added product enriched manure, production of briquettes from loose biomass, production of agricultural products under greenhouse, packaging and storage of value added products, conduct manufacturing and production techniques, organize resources and utilities, sale of product, quality control, instrumentation for taking care of practical exercise, proper methods and procedures for maintenance of records including inventory of materials, maintenance of accounts, management of the enterprise and learning distribution techniques and marketing. Students will trained in:

- Pre-investment and pre-feasibility study
- New project identification
- Project feasibility and market study
- Identification of profitable industrial project opportunities
- Preparation of project profiles
- Preparation of techno-economics feasibility reports
- Identification and selection of plant and machinery
- Manufacturing process and equipments required
- General guidance for establishment, repair and maintenance of renewable energy gudgets
- Technical and commercial counselling
- Investment decision making
- Corporate diversification planning
- Forecasting financial aspects by estimating the cost of raw material, formulating the cash flow statement, projecting the balance sheet etc.
- Marketing and distribution of processed products.
- Federating into business group

Evaluation of students undergoing Hands-on training

S.No.	Activity	Credits
1.	**Preparation of Business Plan**	4
	i. Selection or raw materials/ product to be manufactured & cultivation	
	ii. Innovativeness in the plan	
	iii. Creativity	
	iv Realistic plan	
	v. Overall project report and project presentation	
	vi. Inclusion of basic criteria/making a project concept note/ presentation tool for investment decision enabling environment for task	

S.No.	Activity	Credits
2.	**Organizing the Production**	2
	i. Organization of resources and its management	
	ii. Organizing utility	
	iii. Time management	
	iv. Energy management	
3	**Production and Sales**	3
	i. Regularity in production	
	ii. Product Quality	
	iii. Positioning of product in market	
	iv. Evaluation of presentation	
	v. Adhering to rules and regulations	
	vi. Adhering to plan	
	vii. Cost of production	
4	**Sales**	2
	i. Sales performance	
	ii. Sales volumes	
	iii. Profit generated including B/C ratio, pay back period, etc.	
	iv. Monetizing benefits	
	v. Attempt for reducing costs of production	
5.	**Documentation and Reports**	2
	i. Book keeping	
	ii. People management	
	iii. Preparation of manual	
	iv. Preparation of final report	
	v. Estimation of carbon credit	
6.	**Oral Examination**	3
	i. Presentation	
	Ii. Oral performance	

Sharing of total profit generated

- 50% of the profit will be distributed among students of final year
- Faculty share will be 10% of the profit; faculty includes teaching and non-teaching staff responsible for conducting of hands-on training of 6 months duration
- University will get 20% of the profit and which will be included in the central training fund of the university

- Associate staff including ministerial staff and Class IV will share the 10% of the profit
- Remaining 10% of the profit will be utilized for the development of facilities by head of the institution

Major strengthening of the infrastructure

Civil Works

(A) Building

- Covered platform for housing machine and temporary storage of raw and finished product
- Workshop for maintenance and repairing of different system
- Workshop for dry processing and packaging space
- Storage room for finished products
- Cabins for supervisors and record keeper
- Laboratory space for quality control and for performing various activities

(B) Equipments and Working Utensils

- General Utilities
- Equipment for raw material preparation
- Equipment for testing
- Equipments for analyzing quality etc.
- By-products handing equipments
- Laboratory equipments
- Control equipments i.e. temperature, relative humidity and air flow rate
- Equipments for quality control of value added products
- Equipments for packaging and storage

Experiential Learning Units (ELU) may be propsed in the following areas:

Agriculture Mechanisation

- Hand, Animal drawn and power operated Farm Machines and Equipments / implements and tools: Repair and maintenance
- Establishment of Custom Hiring Centers
- Mechanization for on farm applications
- Mechanization for Horticulture Crops
- Farm Tractor System and its Overhauling
- Pesticides Application Equipment and Tools
- Land Development and Grading Machines

Animal Husbandry and Veterinary Sciences

- Feed and Fodder management
- Densification techniques for fodder: Pellet, Briquettes and Cubs
- Breed improvement
- Animal Health Practices
- Poultry farm raising
- Commercial Broiler Production
- Good Dairy Farming Practices
- Male Weaner Goat rearing
- Veterinary Clinical Practices
- Non – clinical Vascular Infusion Technology
- Veterinary Dentistry
- Clinical Immunology of the Dog and Cat
- AI practice clinics

Agricultural Cooperatives/ Cooperation

- Construction of Godowns for procurement, Storage and distribution
- Farm inputs dealer and Fertilizer Distribution Practices Training

Crop Improvement

- Paddy Breeding and Production
- Wheat Production
- Coarse Cereals Production
- Oilseed and Pulses Production
- Sugarcane Breeding and Production
- Cotton Production
- Integrated Farming Systems
- Good Agricultural Practices
- Crop Improvement in Banana

Dairy Development

- Advanced Dairy Farming Practices
- Promotion and Management of Milk collection Centers
- Organic dairy units
- Processing and Value addition of Milk

Food Processing

- Cereal and Pulses processing
- Fruits and Vegetables Processing
- Chocolate and confectionary manufacturing
- Domestic Product processing
- Drying of Agriculture and Horticulture Products
- Fisheries & Sea product processing
- Development of Consumer Products
- Plantation (Tea, Coffee, Cashew) processing

- Eggs, Poultry & Meat Processing
- Fresh- cut flowers Processing
- Food Packaging
- Functional Foods and Nutraceuticals
- Meat and meat Processing

Agricultural Extension

- Management of KVKs/Knowledge Centers/ ICT enabled KVK
- ARYA, MERA GOAN MERA GAURAV, FARMER FIRST; new initiatives

Fertilisers And Integrated Nutient Management

- Soil testing Labs
- Fertilizer Labs
- Micro-Nutrients Labs
- Soil Health Cards and Soil Testing

Fisheries Sciences

- Farmers Fish Ponds
- Infrastructure / Ponds of Fisheries
- Fish Post harvest Technology

Horticulture

- Nurseries & Green Houses
- Land Scaping and Area Expansion
- Floriculture Production
- Vegetables Production
- Fruits Production
- Coconut Production
- Tissue Culture management
- Commercial Horticulture
- Protected Cultivation of High Value Horticulture Crops
- Precision Farming of Floriculture and Exotic Vegetables
- Development of Quality planting Material

Information Technology

- Development of ICT Facilities
- ICT Enabled Agriculture
- E-Sensors and Micro Processed Based Tools
- Artificial Intelligent and Robotics based wireless sensors and controls
- ICT for Weather Forecasting

Integrated Pest Management

- Establishment of IPM Labs
- Pest Surveillance and Management Techniques

Innovative Programmes

- Conservation Agriculture
- Secondary Agriculture
- Precision Agriculture
- Hi-Tech Agriculture
- Specialty Agriculture
- Poly House/ Net House/ Glass House Management
- Greenhouse Design and Control
- Aeroponics system
- Hydroponics for Growing Plants
- Mushroom Production
- Honey Bee Keeping
- Waste water Treatment
- Integrated Land Use Planning

- Small Dams: Planning, Construction and Maintenance
- Integrated Watershed Management

Marketing & Post Harvest Management

- Godowns & Warehouses Management
- Setting Up/Strengthening of Marketing infrastructure
- Cold Storages & Cold Chains Development

Micro/Minor Irrigation

- Shallow Wells/Dug Wells Irrigation
- Tube wells Operation and Maintenances
- Percolation Tanks and Diggis for Water Storage
- Minor Irrigation Works
- Farm Ponds; Construction and management
- Sprinkler & Drip Irrigation
- Techniques for Canopy under Canopy
- Rainwater Harvesting Structures
- Water and Fertigation Management in micro irrigation
- Closed circuit Trickle Irrigation System
- Sustainable practices in Surface and Subsurface Micro Irrigation

Natural Resource Management

- Water Conservation Structures & Watershed Development
- Soil Treatment Techniques (Acidic, Alkali, Waterlogged)
- Land Reclamation Techniques

Non Farm Activities

- Agri Business Centers
- Post Harvest Processing Facilities

Organic Farming / Biofertiliser

- Production of Bio Fertilizer/ Bio agents and Bio Pesticides
- Composting and Vermi Composting
- NADEP and PROM set up
- Organic and Natural Farming and Marketing of Organic Products
- Waste Recycling and Resource Recovery System
- Zero Budget Farming

Renewable Energy Sources

- Solar Cooking (Direct/Focusing, Indirect/ Box, Advanced type; Steam cooker, solar oven, parabolic type, Separate collector and Cooking chamber type)
- Solar Water Heater (Collector coupled to storage tank, Collector cum storage, Direct natural circulation type solar water heater, Indirect natural circulation type)
- Solar Distillation(Horizontal basin type: single effect & double effect, Tilted tray type)
- Solar Drying (Direct as well as indirect type solar dryer, Natural convection & Forced convection, Green house type)
- Commercial Solar Tunnel Dryer
- Solar Space Heating (Active heating: Solar air Collector and solar liquid collectors, Passive heating: Direct gain type, Thermal storage wall, Attached Sun Space: Trombe wall, water wall, Thermal storage roof system, Connective loop system.

- Solar Refrigeration and Air-Conditioning (Absorption Cycle with liquid absorbents, Absorption cycle with solid absorbents, Absorption cycle with solid absorbents, Vapors compression cycle and natural passive cooling)
- Solar Pond: For Electricity generation & thermal uses.
- Solar Furnaces for Industrial Process Heat (Single len, multiple len, single paraboloid direct type, heliostat type: vertical & horizontal optical axis)
- Solar Greenhouse Technology (Attached type, Free standing & pit type).
- Solar Thermal Power Generation; Centralized tower system, Distributed farm concept type system
- Solar Photovoltaic Technology: Water pumping (Shallow well and Deep well)
- Solar Photovoltaic Technology: Lighting (Domestic: Solar lantern, Street lighting, community centre application: For lighting &TV, Refrigeration)
- Solar Photovoltaic Technology; Power generation: Small stand alone (Few to 1000 watts), large stand alone (1000 w to 3000 w) and central generation system (multi MW production)
- Biomass Densification and Pyrolysis set up
- Biomass Gasification and Application set up
- Improved Cook stoves and Furnaces manufacturing set up
- Energy Audit in Agro Industries

Seed & Planting Material

- Seed Testing Labs
- Seed Processing, Storage and Distribution Centers
- Seed Production and Technology
- Seed Certification
- Tissue Culture set up
- Seed Conditioning set up

Sericulture

- Cocoon Production

Proforma for Submission of Project Proposal under Experiential Learning

1. **Name of the University:**

2. **Title of the Experiential Learning Unit:**

3. **Name of the College with Address:**

4. **Organisational set up of the Unit:**

	Name	**Contact details** (Designation, Mobile No., Email)	**Responsibilities**
Chief Executive Officer			
Managing Director			
Manager			
Faculty			
Guest faculty			

5. **Scope and Objective:**
(Please justify scope for skill learning and employability):

6. **Production Plan /Activity Chart:**
(Month-wise operational activities)

Particulars						
Orientation						
Developing a Business plan						
Training in Advance Skills						
Plan for the production						
Production						
Sales						
Documentation and Reports						
Presentation and Oral Examination						

7. Infrastructure Requirement:

A. Civil Work

S.N.	Activity	Civil work	Cost	Justification	Present Status

Note: Facilities not available may only be demanded

B. List of tools/equipment

S.N.	Activity	Item	Cost	Justification	Present Status

8. Production Targets:

S.N.	Activity	Material produced	Quantity

Note: Production plan for 10 students

9. Economics: (Tentative)
(Accounts shall be maintained regularly)

S.N.	Activity	Production Cost	Gross income	Net profit	Profit share/ student	Profit share of department

10. Marketing Strategy/ Plan including Product Sale:

11. Risk Assessment:

S.N.	Risk identified	Action proposed

12. Monitoring and Evaluation of the EL Unit:
(Give details of inbuilt mechanism)

13. Student Evaluation:
(Attendance, Targets etc)

14. Credit hours /Syllabus:

15. Prospective Private Enterprises for Proposed Partnership:

S.N.	Name of the Agency	Type of Collaboration

16. Product, Production and Marketing related legal aspects, if any:

17. Budgetary Requirements:

(Provide list with item wise cost and other details as Annexure)

S.N.	Particulars	Amount (Rs. in lakh)	Brief Justification
	A. Recurring		
i.	Faculty training		
ii.	Guest lectures		
iii.	Operational expenses (Manpower etc.)		
iv.	Others (Pl specify)		
	Total Recurring		
	B. Non-recurring		
v.	Equipments		
vi.	Works (repair, renovation etc.)		
vii.	Others (raw material etc.)		
	Total Non recurring		
	C. Revolving Fund		
viii.	Name of the item		
	Total Revolving Fund		
	Grand Total (A+B+C) (In Figures)		
	(In Words)		

18. Proposed funding from other sources:

S.N.	Particulars	Amount (Rs. in lakh)	Purpose

19. Attach a brief profile of the core faculty with reference to this programme:

20. Any other information:

CHECK LIST

If Yes please tick (✓) if No please (X)

i. Submission of Demand/ Proposal as per format ☐
ii. UC/AUC of Previous Financial Year ☐
iii. Printed Annual Reports as per format ☐
iv. Head Wise Expenditure in Annexure ☐
v. Present status of EL Units in the University ☐

Signature:_____

Name:_____

Designation:_____

Address:_____

Date: _____

Place: _____

RURAL AWARENESS WORKS EXPERIENCE (RAWE)

General

The scheme envisages the introduction of Rural Awareness Works Experiene (RAWE) programmes in all the Universities curriculum as an essential pre-requisite for the award of the degree to ensure adequate practical training. The RAWE will include precisely prescribed programmes of work in farms as well as KVKs instructional plants etc. for a period of one semester with provision for adequate supervision, reporting and examination at the end. The programme shall be introduced for one semester under the structured degree programmes.

Eligibility

- Students undergoing studies leading to the award of B.Sc. or B.Tech and its equivalent a degree at Agricultural Sciences at Agricultural University shall be eligible for a period of one semester.
- The stipend will be admissible to persons of Indian Nationality as defined in the Constitution of India or persons domiciled in India; irrespective of sex, race or religion.
- A student will be under the administrative control of the Head of the Institution he joins. The Head of the Institution will ensure that all the rules and regulations of ICAR are strictly adhered to.
- A student will devote his whole-time to the approved training and will not be allowed to accept or hold another appointment paid or otherwise.
- If a student shows unsatisfactory progress during the course of his training or gives up the chosen course of studies before its completion without any prior approval of the Head of Institution, or is irregular in attendance, the stipend will be cancelled by the Head of Institute itself. The stipend once cancelled will not be restored, no matter whatever the reasons adduced.
- Good conduct and regularity in attendance are also implied conditions for the continuance of stipend.
- The Head of the Institution is expected to bring to the notice of the Council any adverse report that may have been necessitated due to habitual/ irregularity, misbehaviour, participation in strikes etc. suggesting suspension/ cancellation of stipend. The student will not be paid their stipend during the period of strike or during the period the trainee remains on conduct probation.
- A student undergoing RAWE will not be allowed to avail of any other fellowship/ scholarship during tenure of stipend of the Council. In case a candidate is already receiving any other fellowship/ Scholarship it will be surrendered by him before accepting stipend of the Council. Merit cum means scholarship, Freeship is, however, not covered under the above conditions.

Note: This is not applicable to Veterinary Sciences students.

INTERNSHIP SCHEME FOR VETERINARY SCIENCES

General

The scheme envisage the introduction of Internship programmes in all the Universities in the Veterinary and Animal Sciences curriculum as an essential prerequisite for the award of the degree to ensure adequate practical training. The Internship will include precisely prescribed programmes of work in farms as well as in Veterinary hospitals with provision for adequate supervision, reporting and examination at the end. This programme shall be introduced either in the last semester under the semester pattern or in the last two trimesters under the trimester pattern.

Eligibility

- Students undergoing studies leading to the award of B.V.Sc. and A.H. its equivalent a degree at Veterinary Science College constituent of an Agricultural University shall be eligible for the Internship stipend for a period of six months.
- The Internship will be admissible to persons of Indian Nationality as defined in the Constitution of India or persons domiciled in India, irrespective of sex, race or religion.
- A student will be under the administrative control of the Head of the Institution he/ she joins. The Head of the Institution will ensure that all the rules and regulations of ICAR are strictly adhered to.
- A student will devote his whole time to the approved training and will not be allowed to accept or hold another appointment paid or otherwise.
- If a student shows unsatisfactory progress during the course of his training or gives up the chosen course of studies before its completion without the prior approval of the Head of the Institution, or is irregular in attendance, the internship will be cancelled by the Head of the Institute itself. An internship cancelled will not be restored, no matter whatever the reasons adduced.
- Good conduct and regularity in attendance are also implied conditions for the continuance of internships. The students are not allowed to change the Institute/ College during the tenure of training except with the prior approval of the Head of the College/ Institute.

- The Head of the Institution is expected to bring to the notice of the Council any adverse report that may have been necessitated due to habitual irregularity, misbehaviour, participation in strikes etc. suggesting suspension/ cancellation of internship allowance. The student will not be paid their internship during the period of strike or during the period the interns remain on conduct probation.
- An intern will not be allowed to avail of any other fellowship/ scholarship during tenure of internship of the Council. In case a candidate is already receiving any other fellowship/ Scholarship it will be surrendered by him/her before accepting internship of the Council.

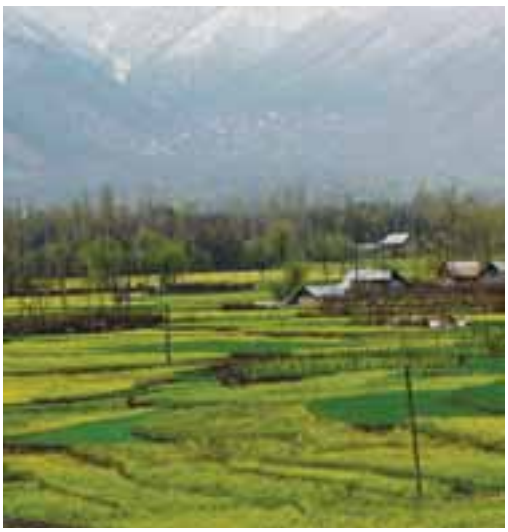
Termination of the Internship

A student will not leave the course before its completion without prior approval of the Head of the Institute. If any student leaves without permission, he/she shall not be paid any fellowship due to him/ her, but not paid to him/ her by the Institution.

Leave

The nature of leave admissible to the students is as follows.

- Six days casual leave for the duration of Internship.
- Special leave for five days for the duration of the Internship on medical; grounds only on full internship allowance.
- In exceptional cases leave up to a maximum of two months on medical ground only without any internship; and
- Maternity leave up to three months to married women interns with full internship allowance on production of Medical Certificate from the Registered Medical Practitioner.
- Leave will not be granted as a matter of right.



STUDENT PROJECT

General

Student Project aims to motivate/encourage and to provide opportunity to the Under-Graduate Students of Agricultural Universities to take up challenges in identification and/or in solution of the problem of the surrounding society related to Agricultural and Allied Sciences and work for better utilization of resources. The participant students shall be able to carry out a project on a topic in relation to a problem of the region. The project should be innovative and activity based, so that the students may develop their ability to solve a societal problem experienced locally using their skill and knowledge. The project will help in creative thinking, observation, ability to raise pertinent questions and predicting solution. This also helps the students how to make field work, to write a scientific report and to present the work.

Eligibility

Under-graduate Students enrolled in Agriculture Universities in Agriculture and Allied Sciences.

Major Areas

Agriculture, Agriculture Engineering, Biotechnology, Dairy Technology, Fisheries, Food Technology, Forestry, Home Science, Horticulture, Sericulture.

A Good Project should have:

i) Originality, Innovation and creativity and should commensurate with understanding the problem and finding solution.

ii) Relevance of the project to the community and impact of the project on society.

iii) Proper understanding of the subject, quality and quantity of the work and efforts to validate the data collected.

Project Report

The structure of the project report shall be in the format is as follows:

i) **The Cover Page -** It should have

- Title of the project
- Name and address of Group Leader and team members
- Name and address of Supervisor/Guide teacher

ii) **Registration Form**

iii) **Abstract -** 500 words

iv) **Contents**

v) **Introduction-** Description on background of the study

vi) **Aims and Objectives**

vii) **Relevance of the project work**

viii) **Methodology**

ix) **Observations:** This shall include the observations during the experiment. Observation can be both qualitative as well as quantitative.

x) **Data analysis and interpretation:** The data generated/ obtained from the experiments/observations should be processed for better understanding in a more structured manner. Tools and methods (e.g. statistical methods) may be used for analysing data to understand the patterns that emerges from it to form results and conclusions.

xi) **Results:** Results are the output of compilation of the data into meaningful outcomes/ interpretations and sometimes, there is a need to redo the experiments to get consistent results. In case it is not possible to "repeat the experiments", there should be adequate replicates so that adequate data is available for interpretation, and arriving at results.

xii) **Conclusions:** This is the logical end of the project to arrive at specific conclusions from the observed phenomena. In a way, the whole objective of the project is to arrive at some conclusion, either positive or negative which would lead to a better understanding of the problem.

xiii) **Acknowledgement**

xiv) **References**

The word limit for the written report should be 5000. The written report can be substantiated by photographs, sketches, illustrations and /or drawings, etc.

Evaluation Criteria

Every project selected by the appropriate authority of the college is to be endorsed and submitted to the Organising body in a sealed confidential envelope. Submitted projects will be evaluated by the technical committee through **Oral presentation.** The projects will be evaluated on the basis of the following criteria:

- Originality of idea and concept
- Relevance of the project to the theme /problem
- Understanding the issue
- Data collection and analysis
- Experimentation/ Validation
- Interpretation
- Oral presentation

Oral Presentation

Oral presentation at the technical session is a very important component of the entire process. Effective communication during the briefing of the issues of study, its objectives, methodology adopted for the study, important observation and findings, vital aspects on the way and approach to solve the problem or addressing the problem is a very critical. Duration of 10 minutes may be allotted for presentation. Therefore, planning is important and students can use power point presentation.

Certificates and Awards

Outstanding students will be given a "Certificate of Merit". However, all students irrespective of categories will be awarded by medals/mementos, along with participation certificates.

GUIDELINES: STUDENT READY (RURAL ENTREPRENEURSHIP AWARENESS AND DEVELOPMENT YOJANA)

(Based on XII Plan)

The Student READY (Rural Entrepreneurship Awareness and Development Yojana) programme aims to provide rural entrepreneurship awareness, practical experience in real-life situation in rural agriculture and creating awareness among undergraduate (UG) students about practical knowledge in agriculture and allied sciences. The programme will help in building confidence, skill and acquire Indigenous Technical Knowledge (ITK) of the locality and thereby, preparing the pass-out for self-employment.

This programme is specially designed for students pursuing Bachelor's degree in agriculture and allied disciplines in the Agricultural Universities of National Agricultural Research and Education System (NARES). The duration programme is for one year which includes Experiential Learning for six months and remaining period is for Rural Awareness Work Experience (RAWE)/ Internship/In Plant Training/Industrial attachment etc. outside the university campus.

The Student READY programme shall commence from academic session 2016-17.

Eligibility

- A student, who is pursuing UG programme in SAUs/DUs/CAU/CUs of NARES in courses duly accredited by the National Agricultural Education Accreditation Board (NAEAB) of ICAR, New Delhi.
- The student must maintain merit and good conduct as certified by the Head of College/University/Institution. He/ She should not remain absent during the programme without prior permission of the Competent Authority.
- The candidate should not participate in any agitation/ strike and should not take up any job even on part time basis or any other financial assistance for the same activities during the period.

Value of Stipend

The stipend payable to the Student shall be Rs. 3,000/- (Rs. 2,500/- as ICAR Share + Rs 500/- as State Share) per student per month for maximum of six months. An amount of Rs. 500/- per student/per month will also be provided as ICAR Share towards operational expenses (meeting faculty expenses, contingency, POL, medicines, etc.) during the programme.

Mode of Payment

- The stipend shall commence from the month a student joins the RAWE/In Plant training/ Internship/ Industrial attachment etc. for maximum period of six months only.
- The University will be paid the money in lump-sum in advance. For this university will have to submit demand to ICAR as per rule well in advance. The University shall transfer the stipend into the student's bank account and ensure the Direct Benefit Transfer (DBT) which will be linked to AADHAR (UID) of the student beneficiary. The university will provide a copy of compiled bank statement to ICAR, New Delhi every year.
- The University must provide the **State Share** (Rs. 500/-per student per month) failing which ICAR may stop grants to the University.
- The student may be paid the stipend on a monthly basis at the end of each month.
- In no case, ICAR will make any payment directly to the student.

Termination of Stipend

The stipend will be terminated, if a student will leave the course before its completion. No stipend will be paid if the student changes discipline or the University without any valid reasons and prior permission of the Competent Authority.

The expenditure involved will be met from the plan funds of ICAR under the scheme "Strengthening & Development of Higher Agricultural Education in India", Sub component: Student READY.

Proforma for Submission of Demand under Student READY (Rural Entrepreneurship Awareness and Development Yojana)

1. Name of the University:

2. Year of Demand:
(Please submit demand for one financial year ONLY)

3. Summary Table:

S.N.	Name of College	Name of Sub-component (RAWE/In-plant Training/ Internship)	No. of Student	Total amount (In Rs.)
1.				
2.				
3.				
4.				
Grand Total			In Figures = In words =	

4. Details of Students (College-wise):

S.N.	Name of the College	Name of Degree programme	Name of Student	University ID/ Roll No.	Year of Admission in the University	RAWE/ In-Plant Training/ Internship	Duration of Stipend (From To)	Amount Claimed (in Rs)
1.								
2.								
3.								
4.								

CHECK LIST

If Yes please tick (✓) if No please (X)

i.	Submission of Demand/ Proposal as per format	☐
ii.	UC/AUC of Previous Financial Year	☐
iii.	Details of students in prescribed format	☐
iv.	College wise & Head wise Expenditure in Annexure	☐
v.	Unspent balance refunded	☐

It is certified that **Student READY**has been implemented in this University and above students are in final year of UG programme. These students are entitled for the above stipend. All demands pertaining to **Student READY**from this university have been compiled and submitted along with above **CHECK LIST.**

Signature:_____

Name:_____

Designation:_____

Address:_____

Date: _____

Place: _____




Contact:
Deputy Director General
Agricultural Education Division
Indian Council of Agricultural Research
Krishi Anusandhan Bhawan-II, PUSA, New Delhi-110 012
Ph.: 011-25841760; E-mail: ddgedn@gmail.com
Website: www.icar.org.in

PROGRAMME (3-15)

M.Sc.

Agriculture & Horticulture

AGRON 501 Modern Concepts in Crop Production 3+0

Objective

To teach the nebasic concepts of soil management and crop production.

Theory

UNIT I

Crop growth analysis in relation to environment; agro-ecological zones of India.

UNIT II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

UNIT III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

UNIT IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress.

UNIT V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.

Suggested Readings

Balasubramaniyan P & Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.

Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.

Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.

Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.

Sankaran S & Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.

Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.

AGRON 502 Soil Fertility and Nutrient Management 2+1

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

UNIT I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

UNIT II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

UNIT III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

UNIT IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.

UNIT V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

Practical

- Determination of soil pH, ECe, organic C, total N, available N, P, K and S in soils Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima

Suggested Readings

Brady NC & Weil R.R 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.

Fageria NK, Baligar VC & Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.

Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Yawalkar KS, Agrawal JP & Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

AGRON 503 Principles and Practices of Weed Management 2+1

Objective

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

UNIT I

Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification; weed indices.

UNIT II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

UNIT III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation.

UNIT IV

Weed management in major crops and cropping systems; parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control.

UNIT V

Integrated weed management; cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops. Preparation of a weed herbarium
- Weed survey in crops and cropping systems Crop-weed competition studies
- Preparation of spray solutions of herbicides for high and low-volume sprayers
- Use of various types of spray pumps and nozzles and calculation of swath width
- Economics of weed control. Herbicide resistance analysis in plant and soil
- Bioassay of herbicide resistance Calculation of herbicidal requirement

Suggested Readings

Aldrich RJ & Kramer RJ. 1997. *Principles in Weed Management*. Panima Publ.

Ashton FM & Crafts AS. 1981. *Mode of Action of Herbicides*. 2nd Ed. Wiley Inter-Science.

Gupta OP. 2007. *Weed Management – Principles and Practices.* Agrobios.

Mandal RC. 1990. *Weed, Weedicides and Weed Control - Principles and Practices*. Agro-Botanical Publ.

Rao VS. 2000. *Principles of Weed Science*. Oxford & IBH.

Subramanian S, Ali AM & Kumar RJ. 1997. *All About Weed Control*. Kalyani.

Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic Press.

AGRON 504 Principles and Practices of Water Management 2+1

Objective

To teach the principles of water management and practices to enhance the water productivity.

Theory

UNIT I

Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

UNIT II

Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition.

UNIT III

Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and polyhouses.

UNIT IV

Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency.

UNIT V

Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

Practical

- Measurement of soil water potential by using tensiometer, and pressure plate and membrane apparatus
- Soil-moisture characteristics curves. Water flow measurements using different devices
- Determination of irrigation requirements. Calculation of irrigation efficiency
- Determination of infiltration rate. Determination of saturated/ unsaturated hydraulic conductivity

Suggested Readings

Lenka D. 1999. *Irrigation and Drainage*. Kalyani

Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.

Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

Prihar SS & Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Singh Pratap & Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

AGRON 511 Cropping Systems and Sustainable Agriculture 2+0

Objective

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

Theory

UNIT I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

UNIT II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

UNIT III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

UNIT IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system.

UNIT V

Plant ideo types for dry lands; plant growth regulators and their role in sustainability.

Suggested Readings

Palaniappan SP & Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.

Panda SC. 2003. Cropping and Farming Systems. Agrobios.

Reddy SR. 2000. Principles of Crop Production. Kalyani.

Sankaran S & Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ. Co.

Singh SS. 2006. Principles and Practices of Agronomy. Kalyani.

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1997. Soil Fertility and Fertilizers. Prentice Hall.

AGRON 512 Dryland Farming and Watershed Management 2+1

Objective

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

UNIT I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

UNIT II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

UNIT III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

UNIT IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

UNIT V

Concept of watershed resource management, problems, approach and components.

Practical

- Seed treatment, seed germination and crop establishment in relation to soil moisture contents
- Moisture stress effects and recovery behaviour of important crops

- Estimation of moisture index and aridity index
- Spray of anti-transparent and their effect on crops
- Collection and interpretation of data for water balance equations
- Water use efficiency
- Preparation of crop plans for different drought conditions
- Study of field experiments relevant to dryland farming
- Visit to dryland research stations and watershed projects

Suggested Readings

Das NR. 2007. *Tillage and Crop Production*. Scientific Publishers.

Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.

Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.

Gupta US. (Ed.). 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH.

Katyal JC & Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.

Rao SC & Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publishers.

Singh P & Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publishing Company.

Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops.* CRIDA.

Singh RP.2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.

Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publishers.

Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

AGRON 513 Principles and Practices of Organic Farming 2+1

Objective

To study the principles and practices of organic farming for sustainable crop production.

Theory

UNIT I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use, minimum tillage; shelter zones, hedges, pasture management, agro-forestry.

UNIT II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers.

UNIT III

Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

UNIT IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides.

UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Aerobic and anaerobic methods of making compost. Making of vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to an organic farm

- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Suggested Readings

Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.

Lampin N. 1990. *Organic Farming*. Press Books, lpswitch, UK.

Palaniappan SP & Anandurai K. 1999. *Organic Farming – Theory and Practice.* Scientific Publ.

Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, Parisaraprajna Parishtana, Bangalore.

Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.

Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.

Singh SP. (Ed.) 1994. *Technology for Production of Natural Enemies.* PDBC, Bangalore.

SubbaRao NS. 2002. *Soil Microbiology*. Oxford & IBH.

Trivedi RN.1993. *A Text Book of Environmental Sciences*, Anmol Publ.

Veeresh GK, Shivashankar K & Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture.* Association for Promotion of Organic Farming, Bangalore.

WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*. WHO.

Woolmer PL & Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

Note : For minor courses please refer the concerned department's courses outline.

Suggested Readings

Beattie BR & Taylor CR. 1985. *The Economics of Production*. John Wiley & Sons.

Doll JP & Frank O. 1978. *Production Economics - Theory and Applications*. John Wiley & Sons.

Gardner BL & Rausser GC. 2001. *Handbook of Agricultural Economics*. Vol. I. *Agricultural Production*. Elsevier. Heady EO. *Economics of Agricultural Production and Resource Use*. Prentice-Hall.

Sankayan PL. 1983. *Introduction to Farm Management*. Tata McGraw Hill.

AG ECON 505 Agricultural Marketing and Price Analysis 2+1

Objective

To impart adequate knowledge and analytical skills in the field of agricultural marketing issues, and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities.

Theory

UNIT I

Review of Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical coordination.

UNIT II

Marketing Co-operatives – APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -

Performance and Strategies – Market infrastructure needs, performance and Government role - Value Chain Finance.

UNIT III

Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service -electronic auctions (e-bay), e-Chaupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) – Market extension.

UNIT IV

Spatial and temporal price relationship – price forecasting – time series analysis –time series models – spectral analysis. Price policy and economic development –non-price instruments.

UNIT V

Theory of storage - Introduction to Commodities markets and future trading -Basics of commodity futures - Operation Mechanism of Commodity markets –Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis -Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios. Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Chain Analysis -quantitative estimation of supply chain efficiency - Market Intelligence –Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports –commodity outlook - Technical Analysis for important agricultural commodities -Fundamental Analysis for important agricultural commodities - Presentation of the survey results and wrap-up discussion.

Practical

Single equation two variable model specification and estimation – hypothesis testing- transformations of functional forms and OLS application-estimation of multiple regression model - hypothesis testing - testing and correcting specification errors - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation - estimation of regressions with dummy variables - estimation of regression with limited dependent variable - identification of equations in simultaneous equation systems.

Suggested Readings

Gujarati DN. 2003. *Basic Econometrics*. McGraw Hill.

Johnson AG Jr., Johnson MB & Buse RC. 1990. *Econometrics - Basic and Applied.* MacMillan.

Kelejan HH & Oates WE. 1994. *Introduction to Econometrics Principles and Applications*. Harper and Row Publ.

Koutsoyianis A. 1997. *Theory of Econometrics.*

Barner & Noble. Maddala GS. 1992. *Introduction to Econometrics.* MacMillan.

Maddala GS. 1997. *Econometrics.* McGraw Hill.

Pindyck RS & Rubinfeld DL. 1990. *Econometrics Models and Econometric Forecasts*. McGraw Hill.

AG ECON 508 Linear Programming 1+1

Objective

The Course Objective of the course is to impart knowledge of Linear programming techniques.

Theory

UNIT I

Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UNIT II

Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

UNIT III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

UNIT IV

Game Theory- Concepts of game theory, two person constant sum, zero sumgame, saddle point, solution to mixed strategies, the rectangular game as Linear Programme.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings

Dorfman R. 1996. *Linear Programming & Economic Analysis*. McGraw Hill.

Loomba NP. 2006. *Linear Programming*. Tata McGraw Hill.

Shenoy G. 1989. *Linear Programming-Principles & Applications*. Wiley Eastern Publ.

Vaserstein. 2006. *Introduction to Linear Programming*. Pearson Education Publication

AG ECON 509 Agricultural Finance and Project Management 2+1

Objective

The Course Objective of the course is to impart knowledge on issues related to lending to priority sector credit management and financial risk management. The course would bring in the various appraisal techniques in project - investment of agricultural projects.

Theory

UNIT I

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing -Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

UNIT II

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

UNIT III

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm.

UNIT IV

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects.Net work Techniques – PERT and CPM.

UNIT V

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather based insurance and their applications.

Practical

Development of Rural Institutional Lending - Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving- : An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme-Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements, Performance of Micro Financing Institutions - NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques – Undiscounted Measures and their limitations. Project appraisal techniques – Discounted Measures, Network techniques – PERT and CPM for project management, Case Study Analysis of an Agricultural project, Financial Risk and risk management strategies – crop insurance schemes, Financial instruments and methods – E banking, Kisan Cards and core banking.

Suggested Readings

Dhubashi PR. 1986. *Policy and Performance - Agricultural and Rural Development in Post Independent India*. Sage Publ.

Gittinger JP 1982. *Economic Analysis of Agricultural Projects***.** The Johns Hopkins Univ. Press.

Gupta SC. 1987. *Development Banking for Rural Development*. Deep & Deep Publ.

Little IMD & Mirlees JA. 1974. *Project Appraisal and Planning for Developing Countries***.** Oxford & IBH Publ.

Muniraj R. 1987. *Farm Finance for Development*. Oxford & IBH Publ.

Note: For minor courses please refer the concerned department's courses outline.

GP 501 Principles of Genetics 2+1

Objective

This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

UNIT I

Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

UNIT II

Multiple alleles, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT III

Population - Mendelian population – Random mating population - Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium.

UNIT IV

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

UNIT V

Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

UNIT VI

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and

transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

UNIT VII

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

UNIT VIII

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

UNIT IX

Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts.

UNIT X

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings

Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.

Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.

Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.

GP 503 Principles of Plant Breeding 2+1

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory

UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.

UNIT II

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III

Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

UNIT IV

Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of

heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT V

Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

UNIT VI

Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII

Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

UNIT VIII

Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Suggested Readings

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation.* Narosa Publ. House.

Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.

Singh BD. 2006. *Plant Breeding*. Kalyani.

Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani.

Singh P. 2006. *Essentials of Plant Breeding*. Kalyani.

Singh S & Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding.*

GP 504 Principles of Quantitative Genetics 2+1

Objective

To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory

UNIT I

Mendelian traits *vs* polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

UNIT II

Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function

and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV

Generation mean analysis; Mating designs- Diallel, partial diallel, line xtester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis– principles and interpretation.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms -interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II –Diallelanalysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : tandard, mid-parental and better-parental heterosis - Estimation of inbreeding depression -Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions -Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis

and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model – Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.

Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.

Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.

Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.

Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding. Kalyani.*

Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.

Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.

Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GP 508 Cell Biology and Molecular Genetics 2+1

Objective

To impart knowledge in theory and practice about cell structure, organelles and their functions, molecules like proteins and nucleic acids.

Theory

UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastidschloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT IV

Transposable elements; Mechanisms of recombination in prokaryote; DN Aorganization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cellaging.

Practical

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaqueassay method; Determination of soluble protein content in a bacterialculture.

Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population inlysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

Suggested Readings

Bruce A. 2004. *Essential Cell Biology*. Garland.

Karp G.2004. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley.

Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman & Co.

Lewin B. 2008. *IX Genes*. John Wiley & Sons

Lodish H, Berk A & Zipursky SL. 2004. *Molecular Cell Biology*. 5th Ed. WH Freeman.

Nelson DL & Cox MM. 2005. *Lehninger's Principles of Biochemistry*. WH F reeman & Co.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Schleif R. 1986. *Genetics and Molecular Biology*. Addison - Wesley Publ. Co.

GP 509 Biotechnology for Crop Improvement 2+1

Objective

To impart knowledge and practical skills to use biotechnological tools incrop improvement.

Theory

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic

hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.),mapping populations (F2s, back crosses, RILs, NILs and DH).

UNIT IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Genepyramiding.

UNIT V

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

UNIT VI

Recombinant DNA technology, transgenes, method of transformation,selectable markers and clean transformation techniques, vector-mediatedgene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases.

UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

UNIT VIII

MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major

countries including India, ethical, legal and social issues; Intellectual property rights

UNIT IX

Bioinformatics & Bioinformatics tools.

UNIT X

Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media –interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gelelectrophoresis of proteins and isozymes, PCR-based DNA markers, gelscoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Suggested Readings

Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA & Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation.* 2nd Ed. Benjamin Publ. Co.

Sambrook J & Russel D. 2001. *Molecular Cloning* - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani

GP 515 Maintenance Breeding and Concepts of Variety Release and Seed Production 1+1

Objective

To apprise the students about the variety deterioration and steps to maintain the purity of varieties & hybrids and principles of seed production in self &cross pollinated crops.

Theory

UNIT I

Variety Development and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid, and population; Variety testing, release and notification systems in India and abroad.

UNIT II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

UNIT III

Factors responsible for genetic deterioration of varieties – safe guards during seed production; Maintenance of varieties in self and cross-pollination crops- isolation distance; Principles of seed production; Methods of nucleus and breeder seed production.

UNIT IV

Generation system of seed multiplication -nucleus, breeders, foundation, certified, - Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

Practical

Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production - Main characteristics of released and notified varieties, hybrids and parental lines; Identification of important weeds/objectionable weeds; Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties indifferent crops; Hybrid seed production technology of important crops.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding. CCS HAU Hisar.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Musil AF. 1967. *Identification of Crop and Weed Seeds*. Handbook No. 219, USDA, Washington, DC.

Poehlman JM & Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.

Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.

Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.

Tunwar NS & Singh SV. 1985. *Handbook of Cultivars*. ICAR.

Note: For minor courses please refer the concerned department's courses outline

ENT 507 Biological Control of Crop Pests and Weeds 1+1

Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

Unit I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation.

Unit II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects.

Unit III

Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation.

Unit IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control.Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Readings

Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman & Hall, New York.

Dhaliwal GS & Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publ., New Delhi.

Gerson H & Smiley RL.1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman & Hall, New York.

Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

Ignacimuthu SS & Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.

Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.

Van Driesche & Bellows TS. Jr. 1996. *Biological Control*. Chapman & Hall, New York.

ENT 508 Toxicology of Insecticides 2+1

Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

Unit I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of

organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, etc.

Unit III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity.

Unit IV

Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

Unit V

Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning. Sprayers, dusters and other plant protection appliances.

Practical

Insecticide formulations and mixtures; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances: Principles, operation and maintenance. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Suggested Readings

Chattopadhyay SB. *1985. Principles and Procedures of Plant Protection.* Oxford & IBH, New Delhi.

Gupta HCL. 1999. *Insecticides: Toxicology and Uses.* Agrotech Publ., Udaipur.

Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Matsumura F. 1985. *Toxicology of Insecticides.*Plenum Press, New York.

Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment.*Narosa Publ. House, New Delhi.

Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

ENT 510 Principles of Integrated Pest Management 1+1

Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM**.** Train students in computation of ETL, implementing IPM programmes.

Theory

Unit I

History and origin, scope and need for IPM, definition and evolution of various related terminologies.

Unit II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

Unit III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses,

unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Visit to IPM fields.

Suggested Readings

Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publ., New Delhi.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology.* Kalyani Publ., New Delhi.

Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management.* 1st Ed., Springer, New York.

Horowitz AR & Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS & Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management.* John Wiley & Sons, New York.

Pedigo RL. 2002. *Entomology and Pest Management.* 4th Ed. Prentice Hall, New Delhi.

Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concepts in Integrated Pest Management.* Prentice Hall, New Delhi.

Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

ENT 511 Pests of Field Crops 1+1

Objective

To familiarize the students about nature of damage and seasonal incidence of insect pests that cause loss to major field crops and their effective management by different methods.

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors.

ENT 518 Techniques in Plant Protection 0+1

Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, electrophoresis etc.

Unit I

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, soaking, root-dip treatment, dusting, spraying, application through irrigation water.

Unit II

Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cutting and cut flower.

Unit III

Use of light transmission and scanning electron microscopy.

Unit IV

Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE .27

Unit V

Use of tissue culture techniques in plant protection.Computer application for predicting/forecasting pest attack and identification.

Suggested Reading

Alford DV. 1999. A *Text book of Agriculture Entomology.* Blackwell Science, London

Cramton JM & Eggleston P.1992. *Insect Molecular Science.* Academic press, London.

Note: For minor courses please refer the concerned department's courses outline.

Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation - Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision – making.

Practical

Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology, study of attributes of current farm technologies, Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology, study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

Suggested Readings

Dasgupta. 1989. *Diffusion Agricultural Innovations in Village India*. Wiley Eastern.

Jalihal KA & Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension* .Concept Publ. Co

Ray GL. 2005. *Extension Communication and Management*. Kalyani Publ.

Reddy AA. 1987. *Extension Education*. Sree Lakshmi Press, Bapatla.

Rogers, E.M. 2003. Diffusion of Innovations.5th Ed. The Free Press, New York.

EXT 504 Research Methods in Behavioural Sciences 2+1

Theory

UNIT I

Research – Meaning, importance, characteristics. Behavioural sciences research – Meaning, concept and problems in behavioural sciences research, Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation,

Experimental, Analytical, Historical, Survey and Case Study. Review of literature – Need, Search Procedure, Sources of literature, planning the review work, Research problem – Selection and Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem.

UNIT II

Objectives – Meaning, types and criteria for judging the objectives. Concept and Construct – Meaning, role of concepts in research and Conceptual frame work development in research. Variable – Meaning, types and their role in research. Definition – Meaning, characteristics of workable definitions, types and their role in research. Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement – Meaning postulates and levels of measurement, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning and methods of testing. Reliability – Meaning and methods of testing. Sampling – Universe, Sample and Sampling- Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors – Methods of elimination and minimizing, Maxi-Min- Con Principle, Sampling – Types of sampling and sampling procedures.

UNIT III

Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each design, Experimental design – Advantages and limitations, Data Collection devices - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires–Meaning, difference between schedule and question-

naire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations. Check lists – Meaning, steps in construction, advantages and limitations in its use. Rating scales– Meaning, types, limits in construction, advantages and limitations in its use. Observation – Meaning, types, tips in observation, advantages and limitations in its use, Case studies – Meaning, types, steps in conducting, advantages and limitations in its use, Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations.

UNIT IV

Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, Statistical Package for Social Sciences (SPSS) choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing – Meaning, guidelines to be followed in scientific report writing, references in reporting

Practical

Selection and formulation of research problem - Formulation of objectives and hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-Development of data collection devices.-Testing the validity and reliability of the data collection instruments: Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, hands on experiences on SPSS, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research, writing report, writing of thesis and research articles-presentation of reports.

Suggested Readings

Chandrakandan K, Venkatapirabu J, Sekar V & Anand Kumar V. 2000. *Tests and Measurements in Social Research*. APH Publ.

Kerlinger FN. 1973. *Foundations of Behavioural Research*. Holt Rhinehart.

Multimedia, Online, Offline Extension, Tools-Mobile technologies, e-learning concepts

UNIT IV

ICT Extension: approaches-pre-requisites, information and science needs of farming community, Need integration, Human resource information, Intermediaries. Basic e-extension training issues, ICT enabled extension pluralism, emerging issues in ICT.

Practical

Agril. Content Analysis of ICT Projects, Handling of ICT tools, Designing extension content, online extension service, and project work on ICT enabled extension, Creation of extension blogs, Visit to ICT extension projects.

Suggested Readings

Batnakar S & Schware R. 2000. *Information and Communication Technology in Development- Cases from India*. Sage Publ.

Meera SN. 2008. *ICTs in Agricultural Extension: Tactical to Practical*. Ganga- Kaveri Publ. House. JangamWadiMath, Varanasi.

Willem Zip. 1994. *Improving the Transfer and Use of Agricultural Information – A Guide to Information Technology*. The World Bank, Washington.

EXT 506 Entrepreneurship Development and Management in Extension (2+1)

Theory

UNIT I

Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development, Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs – Risk taking, Leadership, Decision making,

Planning, Organizing, Coordinating and Marketing, Types of Entrepreneurs Stages of establishing enterprise – Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects

UNIT II

Micro enterprises – Profitable Agri enterprises in India – Agro Processing, KVIC industries, Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development – Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises – Issues relating to success and failure of enterprises – Personal, Production, Finance, Social, Marketing

UNIT III

Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective. Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations.

UNIT IV

Coordination: Concept, Need, Types, Techniques of Coordination, Interpersonal relations in the organization, Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods. Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles, Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication, Managing work motivation – Concept, Motivation and Performance, Approaches to motivation. Supervision –Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision, Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

Practical

Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal -Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions- Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Suggested Readings

Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand & Sons.

Indu Grover. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.

Khanka SS. 1999. *Entrepreneurial Development*. S. Chand & Co.

Singh D. 1995. *Effective Managerial Leadership*. Deep & Deep Publ.

Tripathi PC & Reddy PN. 1991. *Principles of Management*. Tata McGraw Hill.

Vasanta Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.

EXT 507 Human Resource Development 2+1

Theory

UNIT I

Human Resource Development – Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; HRD Interventions – Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment ; Motivation productivity - job description – analysis and evaluation; Performance Appraisal.

UNIT II

Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception; Stress and coping mechanisms; Inter-Personal Process, Helping Process – communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building – Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager – Responsibility of Professional Manager; Managerial skills and Soft Stills required for Extension workers; Decision Making: Decision making models, Management by Objectives; Behavioral Dynamics: Leadership styles – Group dynamics.

UNIT III

Training – Meaning, determining training need and development strategies – Training types, models, methods and evaluation, Facilities for training – Trainers training – techniques for trainees' participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate – organizing for HRD – emerging trends and Prospective.

Practical

Visit to different training organizations to review ongoing activities & facilities; Analysis of Training methods followed by training institutions for farmers and extension workers Studies on evaluation of training programmes; Study of HRD in organization in terms of performance, organizational development, employees' welfare and improving quality of work life and Human resource information, Presentation of reports.

Suggested Readings

Agochiya D. 2002. *Every Trainer's Handbook*.Sage Publ.

David Gross. 1997. *Human Resource Management - The Basics*. TR Publ.

Davis Keth & Newston W John 1989. Human Behaviour at Work. 8th Ed. McGraw-Hill.

Hersey Paul & Balanchard H Kenneth. 1992. *Management of Organizational Behaviour Utilizing Human Resource*. 5th Ed. Prentice-Hall of India.

Knoontz Harold & Weihhrich Heinz 1990. *Essentials of Management*. 5th Ed. McGraw-Hill.

Lynton RP & Pareek U. 1993. *Training for Development*. DB. Taraporewale Sons & Co.

Punna Rao P & Sudarshan Reddy M. 2001. *Human Resource Development Mechanisms for Extension Organization*. Kalyani Publ.

PL PATH 516 Integrated Disease Management 2+1

Objective

To emphasize the importance and need of IDM in the management of diseases of important crops.

Theory

UNIT I

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

UNIT II

Development of IDM- basic principles, biological, chemical and cultural disease management.

UNIT III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed , mustard, pearlmillet, *kharif* pulses, vegetable crops and fruit crops.

Practical

Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in certain crops as project work.

Suggested Readings

Gupta VK & Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004. *Biotechnological Approaches for the Integrated Management of Crop Diseases*. Daya Publ. House, New Delhi. 78

Sharma RC & Sharma JN. (Eds). 1995. *Integrated Plant Disease Management*. Scientific Publ., Jodhpur.

SOILS 503 Soil Chemistry 2+1

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

UNIT I

Chemical (elemental) composition of the earth's crust and soils.

UNIT II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

UNIT III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layertheories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.

UNIT IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange – innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.

UNIT VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

UNIT VII

Chemistry of salt-affected soils and amendments; soil pH, EC_e, ESP, SAR and important relations; soil management and amendments.

UNIT VIII

Chemistry and electrochemistry of submerged soils.

Practical

- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, E_h by the use of E_h-pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Potentiometric and conductometric titration of soil humic and fulvic acids
- (E_4/E_6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Δ (E_4/E_6) values at two pH values
- Adsorption-desorption of phosphate/sulphate by soil using simpleadsorption isotherm
- Construction of adsorption envelope of soils by using phosphate/fluoride/ sulphate and ascertaining the mechanism of the ligand exchange process involved
- Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford and IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.

Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 504 Soil Mineralogy, Genesis, Classification and Survey 2+1

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UNIT I

Fundamentals of crystallography, space lattice, coordination heory, isomorphism and polymorphism.

UNIT II

Classification, structure, chemical composition and properties of clayminerals; genesis and transformation of crystalline and non-crystalline clayminerals; identification techniques; amorphous soil constituents and other on-crystalline silicate minerals and their identification; clay minerals in Indian soils.

UNIT III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

UNIT IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soilmaps – usefulness.

UNIT V

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

UNIT VI

Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes inthe framework of agro-ecosystem.

Practical

- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality
- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

Dixon JB & Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.

Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science.* ISSS, New Delhi.

Sehgal J. 2002. *Introductory Pedology: Concepts and Applications.* New Delhi

Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.

USDA. 1999. *Soil Taxonomy*. Hand Book No**.** 436. 2nd Ed. USDA NRCS, Washington.

Wade FA & Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.

Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*.Elsevier.

Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I. *Concept and Interaction*. Elsevier.

SOILS 506 Soil Biology and Biochemistry 2+1

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV

Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI

Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

- Determination of soil microbial population Soil microbial biomass
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect

Suggested Readings

Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.

Burges A & Raw F. 1967 . *Soil Biology*. Academic Press.

McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.

Metting FB. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.

Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.

Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.

Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill. 92

Stotzky G & Bollag JM. 1993. *Soil Biochemistry*. Vol. VIII. Marcel Dekker.

Sylvia DN. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.

Wild A. 1993. *Soil and the Environment - An Introduction*. Cambridge Univ. Press.

SOILS 510 Remote Sensing and GIS Techniques for Soil, Water and Crop Studies 2+1

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to rigging, and GIS and applications in agriculture.

Theory

UNIT I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.

UNIT II

Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations.

UNIT III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

UNIT IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

UNIT V

Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

- Familiarization with different remote sensing equipments and data products
- Interpretation of aerial photographs and satellite data for mapping of and resources
- Analysis of variability of different soil properties with classical and geostatistical techniques
- Creation of data files in a database programme
- Use of GIS for soil spatial simulation and analysis
- To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.

Lillesand TM & Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.

Nielsen DR & Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.

Star J & Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

SOILS 502 Principle and Practices of Soil Fertility 3+1

Objective

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

UNIT I

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.

UNIT II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

UNIT III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.

UNIT IV

Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

UNIT V

Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

UNIT VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

UNIT VII

Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

UNIT VIII

Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management.

UNIT IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for total and available nutrients
- Analysis of plants for essential elements

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*.John Wiley & Sons.

Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
Hillel D. 1980. *Applications of Soil Physics*.Academic Press.
Hillel D. 1980. *Fundamentals of Soil Physics*.Academic Press.
Hillel D. 1998. *Environmental Soil Physi*cs.Academic Press.
Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
Indian Society of Soil Science. 2002. *Fundamentals of Soil Science.* ISSS, New Delhi.
Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
Kohnke H. 1968. *Soil Physics*.McGraw Hill.
Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
Oswal MC. 1994. *Soil Physics*.Oxford & IBH.
Saha AK. 2004. *Text Book of Soil Physics*. Kalyani.

SOILS 509 Soil, Water and Air Pollution 2+1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

UNIT I

Soil, water and air pollution problems associated with agriculture, nature and extent.

UNIT II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.

UNIT III

Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV

Pesticides – their classification, behavior in soil and effect on soil microorganisms.

UNIT V

Toxic elements–their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

UNIT VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases–carbon dioxide, methane & nitrous oxide.

UNIT VIII

Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

- Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents
- Heavy metals in contaminated soils and plants
- Management of contaminants in soil and plants to safeguard food safety
- Air sampling and determination of particulate matter and oxides of sulphur
- Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect.*CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience. Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.

Vesilund PA & Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

Note : For minor courses please refer the concerned department's courses outline.

MBB 501 PRINCIPLES OF BIOTECHNOLOGY3 (2+1)

Objective: To familiarize the students with the fundamental principles of Biotechnology, various developments in Biotechnology and its potential applications.

Theory

UNIT I History, scope and importance, DNA structure, function and metabolism

UNIT II DNA modifying enzymes and vectors, Methods of recombinant DNA technology Nucleic acid hybridization, Gene libraries; PCR amplification, Plant and animal cell and tissue culture techniques and their applications.

UNIT III Molecular markers and their applications, DNA sequencing: Applications of gene cloning in basic and applied research, Genetic engineering and transgenics, Genomics, transcriptomics and proteomics.

UNIT IV General application of biotechnology in Agriculture, Medicine, Animal husbandry. Environmental remediation. Energy production and Forensics, Public perception of biotechnology, Bio-safety and bioethics issues, Intellectual property rights in biotechnology

Practical

Isolation of genomic and plasmid DNA

Gel electrophoresis techniques

Restriction enzyme digestion, ligation, transformation and screening of transformants PCR and molecular marker analysis

Plant tissue culture media preparation, cell and explant culture, regeneration and transformation

Suggested Readings

UNIT IV Dot blot analysis, Southern hybridization, Northern hybridization, Western blotting and ELISA, Radiation safety and non-radio isotopic procedure.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. Short Protocols in Molecular Biology John Wiley. un LY. 2006. Microbial Biotechnology World Scientific.

Sambrook J. Russel DW & Muniatis T 2001. Molecular Cloning a Laboratory Manual, Cold Spring Harbour Laboratory Press

MBB 507 MOLECULAR BREEDING 2 (2+0)

Objective: To familiarize the students about the use of molecular biology tools in plant breeding.

Theory

UNIT I Principles of plant breeding, Breeding methods for self and cross pollinated crops; Heterosis breeding, Limitations of conventional breeding. Aspects of molecular breeding.

UNIT II Development of sequence based molecular markers SSRs and SNPs, Advanced methods of genotyping, Mapping genes for qualitative and quantitative traits.

UNIT III QTL mapping using structured populations, AB-QTL analysis, Association mapping of QTL, Fine mapping of genes/QTL, Map based

gene/QTL isolation and development of gene based markers, Allele mining by TILLING and Eco-TILLING, Use of markers in plant breeding.

UNIT IV Marker assisted selection (MAS) in backcross and heterosis breeding, Transgenic breeding, Foreground and background selection; MAS for gene introgression and pyramiding MAS for specific traits with examples.

Suggested Readings

Chittaranjan K. 2006-07 Genome Mapping and Molecular Breeding in Plants Vols. IVII Springer.

Newbury HJ. 2003 Plant Molecular Breeding. Blackwell Publ.

Weising K, Nybom H, Wolff K & Kahl G. 2005. DNA Fingerprinting in Plants Principles, Methods and Applications. Taylor & Francis

MBB 510 BIOSAFETY, IPR AND BIOETHICS 2 (2+0)

Objective: To discuss about various aspects of biosafety regulations, IPR and bioethics concems arising from the commercialization of biotech products

Theory

UNIT I Biosafety and risk assessment issues, Regulatory framework, National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm, Risk management issues - containment.

UNIT II General principles for the laboratory and environmental biosafety. Health aspects, toxicology, allergenicity, antibiotic resistance, etc, Impact on environment gene flow in natural and artificial ecologies, Sources of gene escape, tolerance of target organisms, creation of superweeds/super viruses, etc.

UNIT III Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics, Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health, society and the environment.

UNIT IV The WTO and other international agreements, Intellectual properties, copyrights. trademarks, trade secrets, patents, geographical indications, etc. Protection of plant variety and farmers right act, Indian patent act and amendments, patent filing. Convention on biological diversity, Implications of intellectual property rights on the commercialization of biotechnology products

Suggested Readings

Singh BD 2007. Biotechnology Expanding Horizon. Kalyani.

MBB 513 NANO-BIOTECHNOLOGY 3 (3-0)

Objective: Understanding the molecular techniques involved in structure and functions of nano- biomolecules in cells such as DNA, RNA and proteins.

Theory

UNIT I Introduction to Biomacromolecules. The modern concepts to describe the conformationand dynamics of biological macromolecules scattering techniques, micromanipulation techniques, drug delivery applications etc.

UNIT II Cellular engineering signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation

UNIT III Chemical, physical and biological properties of biomaterials and bioresponse biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and tructural proteins); Acrosol properties, application and dynamics, Statistical Mechanics in Biological Systems.

UNIT IV Preparation and characterization of nanoparticles, Nanoparticular carrier systems, Micro-and Nano-fluidics, Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabelic engineering and Gene therapy

Suggested Readings

Nalwa HS. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publ. Niemeyer CM & Mirkin CA. 2005, Nanobiotechnology Wiley Interscience.

MBB 553 BIOSTATISTICS AND COMPUTERS 3 (2+1)

Objective: This is the special course for M.Sc. students of Biotechnology. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT 1 Aims, scope and idea of elementary statistics, Measures of central tendency and dispersion, skewness and kurtosis.

UNIT II Concept of probability and probability laws, mathematical expectation, moments, moments generating function: Standard probability distributions- Binomial, Poisson and Normal distributions

UNIT III Tests of significance based on 2, x2, 1 and F statistics, Correlation and regression, curve fitting by least squares methods.

UNIT IV Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel Statistical Data analysis based on above topics through MS-Excel.

Practical

Data analysis using probability, test of significance Correlation and regression analysis Usage of MS-Windows Exercises on test processing, spreadsheet and DBMS SPSS

Suggested Readings

Agarwal BL. 2003. Basic Statistics. New Age
Gupta SP. 2004. Statistical Methods. S. Chand & Sons.
Dutta NK. 2002. Fundamentals of Bio-Statistics. Kanishka Publ.

MBB 555 INTRODUCTION TO BIOINFORMATICS 3 (2+1)

Objective: To impart an introductory knowledge about the subject of bioinformatics to the students studying any discipline of science.

Theory

UNIT I Introduction, biological databases-primary, secondary and structural, Protein and Gene Information Resources-PIR, SWISSPROT, PDB, gene bank, DDBJ. Specialized genomic resources.
UNIT II DNA sequence analysis, cDNA libraries and EST, EST analysis, pair wise alignment techniques, database searching, multiple sequence alignment. UNIT III Secondary database searching, building search protocol, computer aided drug design -basic principles, docking, QSAR
UNIT IV Analysis packages-commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical
Usage of NCBI resources
Retrival of sequence/structure from databases
Visualization of structures
Docking of ligand receptors
BLAST exercises

Suggested Readings
Attwood TK & Parry-Smith DJ. 2003. Introduction to Bioinformatics. Pearson Education.
Rastogi SC, Mendiratta N & Rastogi P. 2004. Bioinformatics Concepts, Skills and Applications
CBS
Note : For minor courses please refer the concerned department's courses outline.

EVS 501: Fundamentals of Environmental Sciences (2+1)

Objective

To make students familiarize with the basic concepts and principles of environmental science, various ecosystems and its relationship with other components.

Theory

Unit 1

Concepts of Environmental Science

Definition, Scope and importance of Environmental studies – Environmental complex-inter relation to other disciplines-History on resource exploitation and conservation.

Unit 2

Ecosystems

Concept of an ecosystem-Ecosystem types and components-Physical, Chemical and Biological character-Structure and function of an ecosystem-Producers, Consumers and decomposers-distribution and abundance of living systems.

Unit 3

Environmental inter relationship and energy Flow

Interrelationship between environment, microbes, plant and animal systems-energy flow and nutrient cycling-food chain, food web and ecological pyramids- Ecological Succession-Ecological interaction and adaptation- periodicity and biological clock.

Unit 4

Environmental Legislation and Policies of the government

Aims and need of Legislation and Policies-Water Act (1974). Air Act (1981), Environmental protection Act (1986) – conservation of forest and wild life. Other major acts related to Solid wastes and Marine pollution.

Unit 5

Global Environmental Issues

Introduction to Environmental issues- Transboundary issues of Environment; Environmental issues in India; Land degradation- Deforestation – Drought – Desertification; of freshwater resources, over exploitation of ground water and Marine pollution – Environmental issues on the construction of big dams

Practical

Population of terrestrial ecosystem, grassland ecosystem – abiotic factors and biotic factors in terrestrial ecosystem- flora and fauna- aquatic ecosystems- biotic and abiotic factors. Forest ecosystem- flora and fauna- biotic factors influencing forest ecosystem. Energy flow and nutrient cycles in the biosphere. Visits to catchment area / dam site, Regulatory bodies, Water boards, Public health departments, Forest and wild life Departments (biosphere reserve areas), Social organizations, Environmental consultancy firms, etc, NGO's and ETP's of established industries.

Suggested Readings

Agarwala, S.P. 2006 Environmental Studies, Narosa Publishing House, New Delhi.

Erach Bharucha 2005. Text book of Environmental Studies. UGC Publication,

University Press Hydrabad

Prabu, P.C., C.Udayasoorian and G.Balasubramanian. 2009. An Introduction to Ecology and

Environmental Science Abhijeet Publications, New Delhi.

Sharma, P.D. 1995. Ecology and Environment. Restogi Publication, Pune

www.agiweb.org/gap/legis106/neea106.html
https://www.det.nsw.edu.au/.../pd02_49_Environmental_policy.pdf
www.environment.nsw.gov.au/sustainbus/environlegiscompliance.htm
www.dec.wa.gov.au/.../1737-environmental-education-strategy-and-acti.

EVS 502: Instrumental Methods of Environmental Analysis (2+1)

Objective

To impart theoretical and practical knowledge about instrumental techniques used in environmental analysis.

Theory

Unit I

Basic principles of instrumental analysis, principles of electrometric equipments- EC meter, pH meter, ion meter and paleography

Unit II

Spectroscopic techniques used in environmental analysis- UV, visible, flame -emission, absorption, Infra-red, inductively coupled plasma and mass spectrometry

Unit III

Chromatographic techniques in environmental analysis – column, thin layer, gas, high pressure, ion chromatography and electrophoresis

Unit IV

Advanced molecular techniques – Biolog, polymerase chain reaction (PCR)

Unit V

Other techniques of environmental analysis- Kjeltech, particular sampler, infra red gas analyser, BOD and COD kits, fermention technique

– fermentor; Free air carbon dioxide enrichment (FACE) and open top chamber (OTC) techniques

Practicals

Determination of pH and EC, Determination of metals and ion using polarographic analyzer; Heavy metal analysis using AAS; Analysis of group I and II metals using flame photometer; Chromatographic analysis; Microbial activity measurement – Biolog and PCR; Determination of N using Kjeltec; Particulate sampling and analysis; Free air carbon dioxide enrichment studies

Suggested Readings

Environmental instrumentation and analysis handbook by Randy D. Down, Jay H. Lehr

Instrumental Methods Of Analysis, by Willard and Merrit Methods for Environmental Trace analysis by John R. Dean Principles of Instrumental Analysis by Douglas A.

EVS 503: Environmental Chemistry & Ecotoxicology (2+1)

Theory

Unit I

Fundamentals of Environmental Chemistry

Stochimetry, Gibb's energy, Chemical potential, Chemicalquilibria, acid-base, reactions. Solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, Radio nuclides. Classification of elements, chemical speciation, particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermo-chemical and photochemical reactions in the atmosphere. First law of thermodynamics, adiabatic transformations, second law of thermodynamics, Carnot's cycle, entropy, third law of thermodynamics, enzymes catalysis, Michaelis/ Menten equation.

Unit II

Atmospheric Chemistry

Structure and composition of atmosphere – Chemical reactions in the atmosphere. Ozone chemistry – CFC's – Acid Rain – Photochemical smog – Aerosols types – production and distribution – Aerosols and Radiation – temperature inversion – Green House gases – Global warming.

Unit III

Water Chemistry

Water resources, hydrological cycle, physical and chemical properties of water, complexation in natural and waste water, role of microorganisms, Water pollutants – Types – Sources – Heavy metals – Metalloids – Organic – Inorganic – Biological and Radioactive – Types of reactions in various water bodies including marine environment – Eutrophication – Groundwater – Potable water chemistry applications in waste water treatment methods: Coagulation oxidation – H_2O_2, fenton, ozontion, sonication- ion exchange – adsorption membrane filtration.

Unit IV

Soil Chemistry and Green Chemistry

Organic and inorganic – soil, physical and chemical properties – Cation exchange capacity – soil pH – Environmental properties of soils: Leaching and erosion – reactions with acids and bases – Geochemical reactions that neutralize acidity – Biological Process that neutralize acidity – salt affected soil – Trace metals in soils. Principles – tools of Alternative feed stocks starting material alternative reagents, alternative solvents, alternative products and alternative catalysis. Green Environmental issues : Introduction – Ecological and Carbon foot print – Carbon Credits – Carbon Sequestration – Clean Development mechanism (CDM) – Polluters pay – Consumerism – Sustainable mining – Urban forestry – Green buildings – Green building practices – Approaches to green computing – Nanotechnology and Environment.

Unit V

Introduction to Ecotoxicology

Definition, classification of toxicants in environment, factors affecting toxicity, Mutagenesis, Teratogenesis, Carcinogens, Hallucinogens; Phytotoxins and animal toxins; Toxic response of different body system likes respiratory, gastro-intestinal tract, liver, kidney, immune system and reproductive system; Toxicants types; Absorption and distribution of toxicants in animal body' Bio-transformation of toxicants; Antidotes treatment and detoxification of toxicants; Bio-accumulation Toxic chemicals in the environment – air, water and their effects, Pesticides in water, mode of entry of toxic substance, biotransformation of xenobiotics detoxification, Carcinogens in air, chemical carcinogenicity, mechanism of carcinogenicity, Environmental carcinogenicity testing. Toxicants – Dose response relationship – Evaluation methods – LD50 and LC50, MIC and IC50 Dose. Impact of toxic chemicals on Enzymes-Biochemical effects of arsenic, lead, carbon monoxide, Nitrogen oxides, Sulphur dioxide, ozone, PAN, cyanide, pesticides and Carcinogens.

Practicals

Sample preparation – Collection, processing, storage of effluents, sludge, water, soil and plant samples, Estimation of heavy metals (Chromium Lead) in environmental samples, Adsorption/ desorption of pesticides/ herbicides and heavy metals in soil' Determination of air pollutants – NH3, CO2, SO2, N2O – sampling methods and measurements; Estimation of toxic pesticides in soil, crop and water, Fertilizer residues in soil.

Suggested Readings

Andrew, D. Eaton, Lenore. S., Clesceri and W. Eugene and Arnold Greenberg 2005. Standard Methods for Examination of Water and Wasterwater. APHA (USA).

Connell, D.W. 1997. Basic Concepts of Environmental Chemistry. Springer Publication, The Netherlands.

De. A.K. 1992. Environmental Chemistry. Wiley Eastern Ltd., New Delhi.

Ming Ho Yu, H.Tsunoda 2011. Environmental toxicity : Biological and health effects of pollutants. Third edition, CRC press, London, New York PP-1-375.

Willian Harwitz, George and W. Latimer 2005. Official Methods of Analysis published by Association of Officiating Analytical Chemists (AOAC) USA.

e-Resources

http://www.publish.csiro.au

http://www.oficyna.pwr.wroc.pl, oficwyd@pwr.wroc.pl

http:// www. books.pakchem.net/fundamentals-of-environmental-chemistry.html

http:// www .books.pakchem.net/elements-of-environmental-chemistry.html.

http:// www .books.pakchem.net/elements-of-environmental-chemistry.html.

http://www.taylorandfrancis.com

EVS 504: Solid Waste Management (1+1)

Objective

This course deals with different types of solid waste available their characteristics, management techniques, and environmental impact. The infrastructure facilities required for solid waste management, legislation to monitor the program and quality control aspects of this program are all covered in this course.

Theory

Unit I

Availability of different types of solid waste from different sources – its overall characteristics – classification of solid wasters based on their characteristics.

Unit II

Basic techniques in solid waste management program – composting – vermicomposting – energy production – value products – safe disposal of rejected materials.

Unit III

Infrastructure requirement for different solid waste management techniques- machineries involved – management unit plan and financial commitment.

Unit IV

Quality control measures for the product derived from solid waste management – Legislation to monitor solid waste program – Organization involved to monitor the solid waste management program.

Unit V

Legislation in solid waste management – Pollution control board norms – Responsibility of waste generators – impact of solid waste management on environment.

Practicals

Collection of different types of wastes – study the characteristics of waste – composting of biodegradable waste into organic manure and vermicompost – Estimation of nutrient content in the manure – Converting high calorie waste into energy – methane production – Briquette formation – estimation of calorie value – value products – brick making from fly ash – banana fiber extraction from banana waste – Project report preparation for solid waste management program – visit to secured land filling unit – visit to solid waste management unit – Visit to quality control laboratory.

Suggested Readings

Diaz, I.F., M. de Bertoldi and W. Bidlingmaier 2007. Compsot science and technology, Elsevier pub., PP. 1-380.

Hammer, M.J. and M.J. Hammer Jr. 2003. Waste and Waste water Treatment Technology, Prentice Hall of India Pvt. Ltd.

Prabhakar, V.K. 2001. Solid Waste Management. Anmol Pub Pvt. Ltd., New Delhi, PP 286.

Uta Krogmann, Ina Kome and Luis F. Diaz 2010. Solid waste technology and management (Vo. 1 and 2). Blackwel Pub. Ltd. Wiley Online library.

e-Resources

http://www.ec.europa.eu/environment/water/water-urbanwaste/index_en.html

http://www.gewater.com/wastewater-treatment.html

http://www.printsasia.in/book/solid-waste-management-v-k-prabhakar 8126109300-

EVS 505: Waste Water Management (2+1)

Objective

To make the students familiarize with various technologies available for managing the waste water and it's recycling

Theory

Unit I

Water resources and its contamination

Introduction to water resources – Drinking water – water quality in flowing water- impounded waters and ground water quality – Water quality standards – microbiological and chemical quality of drinking water – Characterizations of domestic – industrial – infiltration and inflow and municipal waste water – Wastewater flows, sampling, monitoring and evaluation of waste water.

Unit II

Waste water biology and processing of waste water

Microbiology of waste water and waterborne diseases – Biological treatment systems and biological kinetics- Physical – chemical – biological processing of water.

Unit III

Sewage and industrial waste water

Sewage systems and sewage characteristics – Waste water treatment methods – Types of industrial wastes – sludge treatment and disposal – Microbial metabolism, growth kinetics, aeration and agitation – Bioreactors for waste water treatment – waste water economics – Biotechnology and hazardous waste removal.

Unit IV

Wastewater treatment

Microbiology and bioremediation of waste water treatment-aerobic / anaerobic – energy production – Limitations in conventional treatment – Advanced treatment technologies – Membrane technology – Reed bed systems – Biological nutrient removal.

Unit V

Recycling of wastewater

Monitoring the Quality of treated wastewater – Management options for utilization of treated wastewater for agriculture – Groundwater recharge.

Practicals

Sampling methods – Physical and chemical properties of water and waste water- Biological properties of wastewater – coliforms assay in water and wastewater – Aeration and activated sludge treatment of wastewater – Biomethanation potential of wastewater and microbial communities in waste water treatment system – Visit to sewage treatment plants- Visit to industrial waste treatment plant and biomethanation plants- Practical examination.

Suggested Readings

Arceivala, S.J. 2000. Wastewater Treatment for Pollution Control, Second Edition, TMH, New Delhi.

http://www.gewater.com/wastewater-treatment.html
http://www.thermaxindia.com/water-and-waste-solutions/systems-and-solutions/industrial-effluent-treatment-and-recycling.aspx

EVS 507: Biodiversity & Conservation (1+1)

Objective

To provide a comprehensive knowledge on biodiversity, loss of biodiversity and conservation methods.

Theory

Unit I

Biodiversity and its importance

Biodiversity: Definition, Elements of Biodiversity, measuring biodiversity, Global distribution of flora and fauna, Values of biodiversity, Geographical diversity- Mapping biodiversity, Species-Area relationships; Mega Diversity Regions, Biodiversity Hot Spots, India's Biodiversity.

Unit II

Speciation and Extinction

Concepts of speciation- Anagenesis and cladogenesis –Patterns of Species Biodiversity. Theories on biodiversity – Ecological Niche, Keystone Species, 'K' and 'R' Strategists Species, Immigrant and Indicator Species, New Ecosystems, Endemism and Exotic Species. Historical extinction episodes- Evolution- Natural selection- Adaptive Radiation Causes and processes of extinction-Extinction in India.

Unit III

Agro- Biodiversity

Agro-Biodiversity- Microbial Biodiversity- Conceptual View and General Benefits- Agricultural Development and Biodiversity Links-

Agro-Biodiversity Loss; Conflicts and Effects- Causes of Biodiversity losses linked to Agriculture Diversity through Sustainable Agriculture.

Unit IV

Conservation of Biodiversity

Conservation Methods- Protected Areas- Protected Areas Network In India- National parks and Wildlife Corridors- Biosphere Reserves- MAB- World Heritage-Biosphere Reserves In India- On-Fann and Home Garden Conservation Ex-Stnt Conservation- Tissue Culture and Germplasm Storage- Captive breeding and Reintroduction. Special projects for endangered wildlife- Conservation Plans in India- Sacred Groves.

Unit V

Convention on Biological Diversity

The Convention on Biological Diversity and milstones- CTTES- Free Trade and the Environment – WTO, The Ramsar Convention- IUCN Red List- India's Participation in the International Programmes- biodiversity act.

Practical

Measurement of biotic factors in the terrestrial eco-system- Quadrat method- minimum size of a Quadrat- minimum number of Quadrats- Frequency, abundance and density of plant species in terrestrial eco-system-Determination of biodiversity indices of plant species in terrestrial ecosystem- Line transect method- Belt transect method- Point frame method- Plotless sampling methods- Population size of invertibrates in terrestrial eco-system by mark and recapture methods –Assessment of Earthworm-Microbial diversity in terrestrial and aquatic eco-system- study of planktons in aquatic ecosystem.- Tissue culture and cryopreservation techniques for the conservation of biodiversity – Study tour to a wild life sanctuary (biosphere reserve). Indian Hot spot and polluted habitat.

Definition and concept of climate change and variability; global warming and dimming; science and politics of climate change and international conventions; evidence, scenario and causes of climate change

Unit II Greenhouse gases and mechanism of their production and emission from various agro-ecosystems, source and sinks of GHG; warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases

Unit III

Impact assessment of rise in atmospheric temperature and CO_2 on growth, physiological processes, productivity and quality of different crops, soil health, water availability, insect pest dynamics, crop-weed competition, milk and inland and marine fish production; climate change and loss of biodiversity; spatial and temporal changes in agricultural production in context of climate change.

Unit IV

Evidence and causes of global dimming; causes of global dimming; impact assessment of global dimming on crop productivity, quality and crop- pest interaction.

Unit V

Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on crops; International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints and govt. strategies and policies on climate change management.

Practicals

Measurement of CO_2 from crop fields, Measurement of CH_4 from crop fields, Measurement of N_2O from crop fields, Measurement of O_3 from crop fields, Recent techniques for assessing the impact of high temperature on crops, Recent techniques for assessing the impact of CO_2 fertilization on crops, Recent techniques for assessing the impact of elevated O_3 on crops, Modelling impact of high temperature and CO_2 on crop yield, Modelling impact of high temperature on soil and water, Modelling impact of high CO_2 on soil and water

SUPORTING COURSES FOR PG DEGREE PROGRAMME

STAT 511 STATISTICAL METHODS FOR APPLIED SCIENCES (3+1)

Objective This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of

parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Hotelling's T2 Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D2-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, fitting of orthogonal polynomial regression; applications of dimensionality reduction and discriminant function analysis; Nonparametric tests.

Suggested Readings

Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.

Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan. Morrison DF. 1976.

Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N & Casellan Jr. 1956.

Non-parametric Tests for Behavior Sciences. John Wiley. Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic Statistics Text Book:

http://www.statsoft.com/textbook/stathome.html.

STAT 512 EXPERIMENTAL DESIGNS (2+1)

Objective This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to

understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer. Federer WT. 1985. Experimental Designs. MacMillan.

Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.

Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design.

NON-CREDIT COURSES FOR PG DEGREE PROGRAMME

PGS 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical: Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.) Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective: To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface,

introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.

James HS. 1994. Handbook for Technical Writing. NTC Business Books. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. Speaking English Effectively. MacMillan India.

Richard WS. 1969. Technical Writing. Barnes & Noble. Robert C. (Ed.). 2005.

Spoken English: Flourish Your Language. Abhishek. Sethi J & Dhamija PV. 2004.

Course in Phonetics and Spoken English. 2 nd Ed. Prentice Hall of India. Wren PC & Martin H. 2006.

High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0) (e-Course)

Objective: The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments;

Design Act, 2000; Trademarks Act, 1999;

The Copyright Act, 1957 and amendments;

Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003;

National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective: To acquaint the students about the basics of commonly used techniques in laboratory.

Practical Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES 1+0 (e-Course)

Objective To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.

Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS 506 DISASTER MANAGEMENT 1+0 (e-Course)

Objectives To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: Global warming, Sea level rise, Ozone depletion.

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media.

Central, state, district and local administration; Armed forces in disaster response; Disaster response: Police and other organizations.

Suggested Readings

Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.

Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.

FSC 501 Tropical and Dry Land Fruit Production 2+1

Objective

To impart basic knowledge about the importance and management of tropical and dry land fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops

UNIT I: Mango and Banana

UNIT II: Citrus and Papaya

UNIT III: Guava, Sapota and Jackfruit

UNIT IV: Pineapple, Annonas and Avocado

UNIT V: Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

Suggested Readings

Bose T.K., Mitra S.K. & Rathore D.S. (Eds.). 1988. Temperate Fruits - Horticulture. Allied Publ.

Bose T.K., Mitra SK & Sanyal D. 2001. (Eds.). Fruits -Tropical and Subtropical. Naya Udyog.

Chadha K.L. & Pareek O.P. 1996. (Eds.). Advances in Horticulture. Vols. III-V. Malhotra Publ. House.

Nakasone, H.Y. & Paul, R.E. 1998. Tropical Fruits. CABI.

Peter, K.V. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency.

Pradeep kumar T., Suma B., Jyothibhaskar & Satheesan K.N. 2008. Management of Horticultural Crops. Parts I, II. New India Publ. Agency.

Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.

Singh H.P., Negi, J.P. & Samuel J.C. (Eds.). 2002. Approaches for Sustainable Development of Horticulture. National Horticultural Board.

Singh H.P., Singh, G, Samuel, J.C. & Pathak, R.K. (Eds.). 2003. Precision Farming in Horticulture. NCPAH, DAC/PFDC, CISH, Lucknow.

FSC 502 Subtropical and Temperate Fruit Production 2+1

Objective

To impart basic knowledge about the importance and management of subtropical and temperate fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of

flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops

UNIT I : Apple, pear, quince, grapes

UNIT II : Plums, peach, apricot, cherries, hazelnut

UNIT III : Litchi, loquat, persimmon, kiwifruit, strawberry

UNIT IV : Nuts- walnut, almond, pistachio, pecan

UNIT V : Minor fruits- mangosteen, carambola, bael, wood apple, fig, amun, rambutan, pomegranate

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical, subtropical, humid tropical and temperate orchards, Project preparation for establishing commercial orchards.

Suggested Readings

Bose, T.K., Mitra, S.K. & Sanyol, D. (Ed.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.

Chadha, K.L. & Pareek, O.P. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.

Chadha, K.L. & Shikhamany, S.D. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.

Janick, J. & Moore, J.N. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons.

Nijjar, G.S. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.

Radha, T. & Mathew, L. 2007. Fruit Crops. New India Publ. Agency.

Singh, S., Shivankar, V.J., Srivastava, A.K. & Singh, I.P. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

FSC 503 Biodiversity and Conservation of Fruit Crops 2+1

Objective

Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory

UNIT I

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity.

UNIT II

Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ.*

UNIT III

Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT IV

Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, *Prunus* sp, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, exercise on *ex situ* conservation – cold storage, pollen/seed storage, cryopreservation, visits to National Gene Bank and other centers of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Suggested Readings

Frankel, O.H. & Hawkes, J.G. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press.

Peter, K.V. & Abraham, Z. 2007. Biodiversity in Horticultural Crops. Vol. I. Daya Publ. House.

Peter, K.V. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House.

FSC 504 Canopy Management in Fruit Crops 1+1

Objective

To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory

UNIT I

Canopy management - importance and advantages; factors affecting canopy development.

UNIT II

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.

UNIT III

Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion.

UNIT IV

Canopy management through plant growth inhibitors, training and pruning and management practices.

UNIT V

Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practical

Study of different types of canopies, training of plants for different canopy types, canopy development through pruning, use of plant growth inhibitors, geometry of planting; study on effect of different canopy types on production and quality of fruits.

Suggested Readings

Chadha, K.L. & Shikhamany, S.D. 1999. The Grape, Improvement, Production and Post Harvest Management. Malhotra Publ. House.

Pradeep kumar T., Suma, B., Jyothibhaskar & Satheesan, K.N. 2008. Management of Horticultural Crops. New India Publ. Agency.

FSC 505 Propagation and Nursery Management for Fruit Crops 2+1

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

UNIT I

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

UNIT II

Seed quality, treatment, packing, storage, certification, testing. Asexual propagation – rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

UNIT III

Budding and grafting – selection of elite mother plants, methods. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

UNIT IV

Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

UNIT V

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation,

culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Suggested Readings

Hartmann, H.T. & Kester, D.E. 1989. Plant Propagation – Principles and Practices. Prentice Hall of India.

Bose, T.K., Mitra, S.K. & Sadhu, M.K. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash.

Peter, K.V. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.

Singh, S.P. 1989. Mist Propagation. Metropolitan Book Co.

Rajan, S. & Baby, L.M. 2007. Propagation of Horticultural Crops. New India Publ. Agency.

Radha, T. & Mathew. L. 2007. Fruit Crops. New India Publ. Agency.

FSC 506 Breeding of Fruit Crops 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops

UNIT I: Mango, banana and pineapple

UNIT II: Citrus, grapes, guava and sapota

UNIT III: Jackfruit, papaya, custard apple, aonla, avocado and ber

UNIT IV: Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts

UNIT V: Apple, pear, plums, peach, apricot, cherries and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement

Suggested Readings

Bose, T.K., Mitra, S.K. & Sanyol, D. (Eds.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.

Chadha, K.L. & Pareek, O.P. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.

Chadha, K.L. & Shikhamany, S.D. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.

Janick, J. & Moore, J.N. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons.

Nijjar, G.S. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.

Radha, T. & Mathew, L. 2007. Fruit Crops. New India Publ. Agency.

Singh, S., Shivankar, V.J., Srivastava, A.K. & Singh, I.P. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

VSC 501 Production Technology of cool season Vegetable Crops 2+1
Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I

Potato

UNIT II

Cole crops: cabbage, cauliflower, knol khol, sprouting broccoli and Brussels sprout

UNIT III

Root crops: carrot, radish, turnip and beetroot

UNIT IV

Bulb crops: onion and garlic

UNIT V

Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ polyhouse.

Salunkhe DK & Kadam SS. (1998). *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.

Shanmugavelu KG. (1989). *Production Technology of Vegetable Crops*. Oxford & IBH.

Singh DK. (2007). *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co. Lucknow

Singh SP. (1989). *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre, Karnal

Thamburaj S & Singh N. (2004). *Vegetables, Tuber Crops and Spices.* ICAR, New Delhi.

Thompson HC & Kelly WC. (1978). *Vegetable Crops*. Tata McGraw-Hill.

VSC 502 Production Technology of warm season Vegetable Crops 2+1

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:

UNIT I
Tomato, eggplant, hot and sweet peppers

UNIT II
Okra, beans (French bean, Indian bean and cluster bean), cowpea

UNIT III
Cucurbitaceous crop

UNIT IV
Tapioca, sweet potato and colocasia

UNIT V
Green leafy warm season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Readings

Bose TK & Som MG. (1986). *Vegetable Crops in India*. Naya Prokash, Calcutta.

Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. (2003). *Vegetable Crops*. Vols. I-III. Naya Udyog.

Bose TK, Som MG & Kabir J. (2002). *Vegetable Crops*. Naya Prokash, Kolkata.

Brown HD & Hutchison CS. *Vegetable Science*. JB Lippincott Co.

Chadha KL & Kalloo G. (1993-94). *Advances in Horticulture*. Vols.V-X. Malhotra Publ. House, New Delhi.

Chadha KL. (2002). *Hand Book of Horticulture*. ICAR, New Delhi.

Chauhan DVS. (1986). *Vegetable Production in India*. Ram Prasad & Sons.

Decoteau DR. (2000). *Vegetable Crops*. Prentice Hall, New Delhi.

Edmond JB, Musser AM & Andrews FS. (1964). *Fundamentals of Horticulture*. Blakiston Co

Fageria MS, Choudhary BR & Dhaka RS. (2000). *Vegetable Crops: Production Technology*. Vol. II. Kalyani publishers, New Delhi.

Gopalakrishanan TR. (2007). *Vegetable Crops*. New India Publ. Agency, New Delhi.

Hazra P & Som MG. (1999). *Technology for Vegetable Production and Improvement*. Naya Prokash, Kolkata

VSC 503 Breeding of Vegetable Crops 2+1

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Brinjal, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

UNIT V

Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops.

Practical

Preparation of solutions of plant growth substances and their application; experiments in breaking and induction of dormancy by chemicals; induction of parthenocarpy and fruit ripening; application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables; growth analysis techniques in vegetable crops.

Suggested Readings

Bleasdale JKA. (1984). *Plant Physiology in Relation to Horticulture*. 2nd Ed. MacMillan.

Gupta US. (1978). *Crop Physiology*. Oxford & IBH.

Krishnamoorti HN. (1981). *Application Plant Growth Substances and Their Uses in Agriculture*. Tata-McGraw Hill.

Peter KV. (2008). *Basics of Horticulture*. New India Publ. Agency, New Delhi.

Saini RS, Sharma KD, Dhankhar OP & Kaushik RA. (2001). *Laboratory Manual of Analytical Techniques in Horticulture*. Agrobios.

Wien HC. (1997). *The Physiology of Vegetable Crops*. CABI.

VSC 505 Seed Production Technology of Vegetable Crops 2+1

Theory

UNIT I

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behavior, seed development and maturation; methods of hybrid seed production.

UNIT III

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT VI

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops;

seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Suggested Readings

Agrawal PK & Dadlani M. (1992). *Techniques in Seed Science and Technology*. South Asian Publ.

Agrawal RL. (1997). *Seed Technology*. Oxford & IBH.

Bendell PE. (1998). *Seed Science and Technology: Indian Forestry Species*. Allied Publ.

Fageria MS, Arya PS & Choudhary AK. (2000). *Vegetable Crops: Breeding and Seed Production*. Vol I. Kalyani Publishers, New Delhi.

George RAT. (1999). *Vegetable Seed Production*. 2nd Ed. CABI.

Kumar JC & Dhaliwal MS. (1990). *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.

More TA, Kale PB & Khule BW. (1996). *Vegetable Seed Production Technology*. Maharashtra State Seed Corp.

Rajan S & Baby L Markose. (2007). *Propagation of Horticultural Crops*. New India Publ. Agency.

Singh NP, Singh DK, Singh YK & Kumar V. (2006). *Vegetable Seed Production Technology*. International Book Distributing Co., Lucknow.

Singh SP. (2001). *Seed Production of Commercial Vegetables.* Agrotech Publ. Academy.

VSC 507 Production Technology of Underexploited Vegetable Crops 2+1

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

UNIT I

Asparagus, Jerusalem artichoke, leek and drumstick

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale, Globe artichoke, tannia and curry leaf.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathua (chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, dioscorea (greater yam, lesser yam and white yam), yam bean, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, oriental pickling melon, little gourd (kundru), arrowroot and chinese potato.

Practical

Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of under exploited vegetables.

Suggested Readings

Bhat KL. (2001). *Minor Vegetables - Untapped Potential*. Kalyani Publishers, New Delhi.

Indira P & Peter KV. (1984). *Unexploited Tropical Vegetables*. Kerala Agricultural University, Kerala.

Peter KV. (2007-08). *Underutilized and Underexploited Horticultural Crops*. Vols. I-IV. New India Publ. Agency, New Delhi.

Rubatzky VE & Yamaguchi M. (1997). *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. (2001). *Minimal Descriptors of Agri-Horticultural Crops*. Part-II: *Vegetable Crops*. NBPGR, New Delhi.

VSC 508 Organic Vegetable Production Technology 1+1

Theor

UNIT I

Importance, principles, perspective, concept and component of organic production of vegetable crops.

UNIT II

Organic production of vegetables crops, *viz*., solanaceous crops, cucurbits, cole crops, root and tuber crops.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavya, Biodynamics, preparation etc Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export -opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waster management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

Dahama AK. (2005). *Organic Farming for Sustainable Agriculture.* 2nd Ed. Agrobios, Jodhpur.

PSMA 501 Production of Plantation Crops 2+1

Objective

To impart basic knowledge about the importance and production technology of plantation crops grown in India.

Theory

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

Crops

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Wattle and betel vine

Practical

Description of botanical and varietal features, selection of mother palms and seedlings in coconut and arecanut, soil test crop response studies and manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, Visit to plantations.

Suggested Readings

Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.

Chopra VL & Peter KV. 2005. *Handbook of Industrial Crops*. Panima.

Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.

Kurian A & Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.

Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.

Peter KV. 2002. *Plantation Crops*. National Book Trust.

Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. Part I, II. New India Publ. Agency.

Rai PS & Vidyachandram B. 1981. *Review of Work Done on Cashew*. UAS, Research Series No.6, Bangalore.

Ranganathan V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.

Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford & IBH.

Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

PSMA 502 Production Technology of Spice Crops 2+1

Objective

To impart basic knowledge about the importance and production technology of spices grown in India.

Theory

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision

farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of:

UNIT I

Black pepper, cardamom

UNIT II

Clove, cinnamon and nutmeg, allspice

UNIT III

Turmeric, ginger and garlic

UNIT IV

Coriander, fenugreek, cumin, fennel, ajowain, dill, celery

UNIT V

Tamarind, garcinia and vanilla

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice crops.

Suggested Readings

Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.

Arya PS. 2003. *Spice Crops of India*. Kalyani.

Bhattacharjee SK. 2000. *Hand Book of Aromatic Plants*. Pointer Publ.

Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. *Tropical Horticulture*. Vol.I. Naya Prokash.

Chadha KL & Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*. Malhotra Publ. House.

Gupta S. (Ed.). *Hand Book of Spices and Packaging with Formulae*. Engineers India Research Institute, New Delhi.

Kumar NA, Khader P, Rangaswami & Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH.

Nybe EV, Miniraj N & Peter KV. 2007. *Spices*. New India Publ. Agency.

Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.

Peter KV. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA

Pruthi JS. (Ed.). 1998. *Spices and Condiments*. National Book Trust

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.

Purseglove JW, Brown EG, Green CL & Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Tiwari RS & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.

Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

PSMA 503 Production Technology for Medicinal and Aromatic Crops 2+1

Objective

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

Theory

UNIT I

Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production.

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera*, *Phyllanthus amarus*, *Andrographis paniculata.*

UNIT III

Production technology for Medicinal solanum, Isabgol, Poppy, Safed musli, *Stevia rebaudiana*, *Mucuna pruriens*, *Ocimum sp.*

UNIT IV

Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI

Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT VII

Production technology for palmarosa, lemongrass, citronella, **v**ettiver, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, oreganum.

UNIT VIII

Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations.

UNIT IX

Institutional support and international promotion of essential oil and perfumery products.

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units – Visit to CIMAP.

Suggested Readings

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Aromatic Plants*. RRL, CSIR, Jammu.

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Farooqi AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.

Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.

Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Khan IA & Khanum A. *Role of Bio Technology in Medicinal and Aromatic Plants*. Vol. IX. Vkaaz Publ.

Kurian A & Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

PSMA 505 Breeding of Medicinal and Aromatic Crops 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

UNIT I

Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.

UNIT II

Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.

UNIT III

Achievements and prospects in breeding of medicinal crops, *viz*. *Cassia angustifolia*, *Catharanthus roseus*, *Gloriosa superba*, *Coleus forskohlii*, Stevia, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata*, *Dioscorea* sp.

UNIT IV

Prospects in breeding of medicinal crops, *viz*. *Chlorophytum* sp, *Rauvolfia serpentina*, *Aloe vera*, *Ocimum* sp, *Phyllanthus amarus*, *Solanum* sp.

UNIT V

Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint.

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

Suggested Readings

Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Chadha KL & Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Julia F & Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas Publ.

Kurian A & Asha Sankar, M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Prajapati ND, Paero Hit SS, Sharma AK, Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios (India).

Skaria P Babu. 2007. *Aromatic Plants*. New India Publ. Agency.

Thakur RS, Pauri HS & Hussain A. 1989. *Major Medicinal Plants of India* CSIR.

PSMA 507 Organic Spice and Plantation Crop Production Technology 2+1

Objective

To educate principles, concepts and production of organic farming in spice and plantation crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of spice and plantation crops.

UNIT II

Organic production of spice crops and plantation crops, *viz.* pepper, cardamom, turmeric, ginger, cumin, vanilla, coconut, coffea, cocoa, tea, arecanut.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc.; Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waster management, organic soil

amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

Dahama AK. 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.

Gehlot G. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection*. Agrobios.

Palaniappan SP & Annadorai K. 2003. *Organic Farming: Theory and Practice*. Scientific Publ.

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. New India Publ. Agency.

Shivashankar K. 1997. *Food Security in Harmony with Nature*. 3rd IFOAMASIA,

Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore.

Note : For minor courses please refer the concerned department's courses outline .

Practical

Description of botanical features– Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Chadha KL & Choudhury B.1992. *Ornamental Horticulture in India.* ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Chaudhary RC. 1993. *Introduction to Plant Breeding.* Oxford & IBH.

Singh BD. 1990. *Plant Breeding*. Kalyani.

FLA 502 Production Technology of Cut Flowers 2+1

Objective

To impart basic knowledge about the importance and production technology of cut flowers grown in India.

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

UNIT II

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering.

UNIT III

Flower production – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.

UNIT IV

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT V

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops

Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages and fillers.

Practical

Botanical description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental horticulture*. Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL & Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.52

Lauria A & Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 503 Production Technology for Loose Flowers 2+1

Objective

To impart basic knowledge about the importance and management of loose flowers grown in India.

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques

UNIT II

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

UNIT III

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

UNIT IV

Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packing and storage, value addition, concrete and essential oil extraction, trasportation and marketing, export potential, institutional support, Agri Export Zones. **Crops:** Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental Horticulture*. Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash. 53

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

FLA 504 Land Scaping and Ornamental Gardening 2+1

Objective

Familiarization with principles and practices of landscaping and ornamental gardening.

Theory

UNIT I

Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, informal and free style gardens.

UNIT II

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates.

UNIT III

Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants.

UNIT IV

Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves.

UNIT V

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Selection of ornamental plants**,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sabina GT & Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.

Valsalakumari et al. 2008. *Flowering Trees*. New India Publ. Agency.

Woodrow MG.1999. *Gardening in India.* Biotech Books.

FLA 505 Protected Floriculture 2 + 1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific

designs; Structural components; Suitable flower crops for protected cultivation.

UNIT II

Environment control – management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

UNIT III

Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM.

UNIT IV

Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

Practical

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, postharvest handling, packing methods, project preparation, visit to commercial greenhouses.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nelson PV. 1978. *Green House Operation and Management*. Reston Publ. Co.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 506 Value Addition in Flowers 2+1

Objective

To develop understanding of the scope and ways of value addition in flowers.

Theory

UNIT I

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.

UNIT II

Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations.

UNIT III

Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.

UNIT IV

Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

Practical

Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc.; Visit to dry flower units, concrete and essential oil extraction units.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Chadha KL.1995. *Advances in Horticulture*. Vol.XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 507 Turfing and Turf Management 2+1

Objective

To develop understanding of the principles and management of turfing.

Theory

UNIT I

Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT II

Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens.

UNIT III

Preparatory operations; Growing media used for turf grasses – Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT IV

Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing -- mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Practical

Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic

stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics.

Suggested Readings

Nick-Christians 2004. *Fundamentals of Turfgrass Management*. www.amazon.com

Chadha KL & Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A & Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India.* Allied Publ.

Sheela VL. 2007. *Flowers in Trade*. New India Publ. Agency.

Valsalakumari PK, Rajeevan PK, Sudhadevi PK & Geetha CK. 2008. *Flowering Trees*. New India Publ. Agency.

Note : For minor courses please refer the concerned department's courses outline.

SUPORTING COURSES FOR PG DEGREE PROGRAMME

STAT 511 STATISTICAL METHODS FOR APPLIED SCIENCES (3+1)

Objective This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance

of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Hotelling's T2 Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D2-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, fitting of orthogonal polynomial regression; applications of dimensionality reduction and discriminant function analysis; Nonparametric tests.

Suggested Readings

Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.

Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan. Morrison DF. 1976.

Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N & Casellan Jr. 1956.

Non-parametric Tests for Behavior Sciences. John Wiley. Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic Statistics Text Book:

http://www.statsoft.com/textbook/stathome.html.

STAT 512 EXPERIMENTAL DESIGNS (2+1)

Objective This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.

NON-CREDIT COURSES FOR PG DEGREE PROGRAMME

PGS 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical: Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.) Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective: To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations,

photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.

James HS. 1994. Handbook for Technical Writing. NTC Business Books. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. Speaking English Effectively. MacMillan India.

Richard WS. 1969. Technical Writing. Barnes & Noble. Robert C. (Ed.). 2005.

Spoken English: Flourish Your Language. Abhishek. Sethi J & Dhamija PV. 2004.

Course in Phonetics and Spoken English. 2 nd Ed. Prentice Hall of India. Wren PC & Martin H. 2006.

High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0) (e-Course)

Objective: The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographicalindications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments;

Design Act, 2000; Trademarks Act, 1999;

The Copyright Act, 1957 and amendments;

Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003;

National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective: To acquaint the students about the basics of commonly used techniques in laboratory.

Practical Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing

of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES 1+0 (e-Course)

Objective To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Cooperatives, Voluntary Agencies/Non Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.

Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.

Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS 506 DISASTER MANAGEMENT 1+0 (e-Course)

Objectives To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil management and crop production

Suggested Reading

- Balasubramaniyan P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
- Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
- Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.
- Sankaran S and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Alvin PT and kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
- Gardner PP, Pearce GR and Mitchell RL. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- Lal R. 1989. Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. *Advances in Agronomy* 42: 85-197.
- Wilsie CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

Course Title : Principles and Practices of Soil Fertility and Nutrient Management

Course Code :Agron 502

Credit Hours : 2+1

Aim of the course : To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients;

economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil fertility and management

Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

Course Title : Principles and Practices of Weed Management

Course Code :Agron 503

Credit Hours : 2+1

Aim of the course : To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

Unit I

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and classification management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use ofnano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combinationand rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management-robotics, use of drones and aeroplanes, organic etc., cost: benefit analysis of weed management.

Practical

• Identification of important weeds of different crops, Preparation of a weed herbarium, Weed survey in crops and cropping systems, Crop-weed

competition studies, Weed indices calculation and interpretation with data, Preparation of spray solutions of herbicides for high and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil,

- Bioassay of herbicide resistance residues,
- Calculation of herbicidal herbicide requirement

Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit to identify weeds.

Learning outcome

Basic knowledge on weed identification and control for crop production

Suggested Reading

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.
- Chauhan B and Mahajan G. 2014. Recent Advances in Weed Management. Springer.
- Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi).
- Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.
- Jugulan, Mithila (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley
- Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.
- Walia US. 2006. Weed Management, Kalyani.
- Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub.

Course Title : Principles and Practices of Water Management

Course Code :Agron 504

Credit Hours : 2+1

Aim of the course : To teach the principles of water management and practices to enhance the water productivity

Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-waterplant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and losses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their

layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity.

Estimation of upward flux of water using tensiometer and from depth ground water table

- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method
- Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome

Basic knowledge on water management for optimization of crop yield

Suggested Reading

- Majumdar DK. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers
- Mukund Joshi. 2013. A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers
- Lenka D. 1999. Irrigation and Drainage. Kalyani.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi. • Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Prihar SS and Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Singh Pratap and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

Course Title : Cropping Systems and Sustainable Agriculture

Course Code :Agron 511

Credit Hours : 2+0

Aim of the course : To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

Theory

Unit I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

Unit III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

Unit IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Unit VI

Artificial Intelligence- Concept and application.

VII. Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment.

VIII. Learning outcome

Basic knowledge on cropping system for sustainable agriculture.

IX. Suggested Reading

• Panda SC. 2017. Cropping Systems and Sustainable Agriculture. Agrobios (India)
• Panda SC. 2018. Cropping and Farming Systems. Agrobios.
• Palaniappan SP and Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.
• Panda SC. 2003. Cropping and Farming Systems. Agrobios.
• Reddy SR. 2000. Principles of Crop Production. Kalyani.
• Sankaran S and Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ. Co.
• Singh SS. 2006. Principles and Practices of Agronomy. Kalyani
• Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1997. Soil Fertility and Fertilizers. Prentice Hall.

Course Title : Dryland Farming and Watershed Management

Course Code. :Agron 512

Credit Hours : 2+1

Aim of the course : To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

Unit I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Unit IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit V

Concept of watershed resource management, problems, approach and components.

Practical

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET by Penman Monteith Method

- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method
- Assessment of drought
- Estimation of length of growing period
- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency
- Visit to dryland research stations and watershed projects

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment.

Learning outcome

Basic knowledge on dry land farming and soil moisture conservation.

Suggested Reading

- Reddy TY. 2018. Dryland Agriculture Principles and Practices, Kalyani publishers
- Das NR. 2007. Tillage and Crop Production. Scientific Publ.
- Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.
- Dhruv Narayan VV. 2002. Soil and Water Conservation Research in India. ICAR.
- Gupta US. (Ed.). 1995. Production and Improvements of Crops forDrylands. Oxford & IBH.
- Katyal JC and Farrington J. 1995. Research for Rainfed Farming. CRIDA.
- Rao SC and Ryan J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publ.
- Singh P and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ. Company.
- Singh RP. 1988. Improved Agronomic Practices for Dryland Crops. CRIDA.

• Singh RP. 2005. Sustainable Development of Dryland Agriculture in India. Scientific Publ.
• Singh SD. 1998. Arid Land Irrigation and Ecological Management. Scientific Publ.
• Venkateshwarlu J. 2004. Rainfed Agriculture in India. Research and Development Scenario. ICAR.

Course Title : Principles and Practices of Organic Farming

Course Code :Agron 513

Credit Hours : 2+1

Aim of the course : To study the principles and practices of organic farming for sustainable crop production.

Theory

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops andcrop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry trees and trees for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field
- Visit to a biogas plant
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment. exposure visit

Learning outcome

Basic knowledge on organic farming for sustainable agriculture and development of entrepreneurship on organic inputs.

Suggested Reading

- Ananthakrishnan TN. (Ed.). 1992. Emerging Trends in Biological Control of Phytophagous Insects. Oxford & IBH.
- Gaur AC. 1982. A Manual of Rural Composting, FAO/UNDP Regional Project Document, FAO.

AGRICULTURAL ECONOMICS

Course Title : Micro Economic Theory and Applications
Course Code AEC-501
Credit Hours : 3+0

Why this course?

Markets form an integral part of the economy. They are governed by demand and supply mechanism with profit making its ultimate goal. Thus, it is imperative to expose the students towards how the markets function, their types and how the buyers and sellers behave. That will help them make correct decision when it comes to price setting and choice of product.

Aim of the course :

The course envisages the concepts and principles embodying micro-economics. The economic problems, functioning of price mechanism, theory of household behaviour and consumer's demand function. Theory of firm, supply determinants, determination of price under different market structures and factor pricing (micro economic components).

Organisation of the course

The course is organised as follows:

No	Block	Unit
1.	Introduction to micro-economics	1. Basic Concepts: A review
2.	Insight of consumer, production	1. Consumer Choice and cost involved
		2. Production and Cost
3.	Overview of market	1. Market Forms
		2. Factor Markets

Theory

Block 1: Introduction to micro-economics

Unit 1: Basic Concepts: A review

Scarcity and Choice; Production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/ supply schedule and demand/ supply

curve; market versus individual demand/ supply; shifts in the demand/ supply curve

Block 2- Insight of consumer, production and cost involved

Unit 1:Consumer Choice

Cardinal Utility Approach – Ordinal Utility Approach -Budget sets and Preferences under different situations – Hicks and Slutsky income and substitution effects – Applications of Indifference curve approach – Revealed Preference Hypothesis – Consumer surplus – Derivation of Demand curve – Elasticity of demand – Demand and supply together; how prices allocate resources; controls on prices – price floor and price ceiling – applications in agriculture.

Unit 2: Production and Cost

Production functions: single variable - average and marginal product, variable proportions, stages of production. Two variables - isoquants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization; Elasticity of substitution. Expansion path and the cost function Concept of economic cost; Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit.

Block 3: Overview of market

Unit 1: Market Forms

Behaviour of profit maximizing firms and the production process- Perfect competition: Equilibrium of the market. Long run industry supply, applications: effects of taxes and subsidies; Monopoly: Equilibrium; supply; multiplant firm; monopoly power; deadweight loss; price discrimination; Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition. Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg‘s model, Bertrand model; Oligopoly.

Unit 2: Factor Markets

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for

labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent.

Teaching Methods/ Activities

• Lectures • Case studies • Assignments (Group/individual) • Group Discussions on practises done by firms. • Power point presentations by students. • Exploring the agricultural market and identification of industries and their type.

Learning outcome

After completion of the course the student will be able to: • Get acquainted with the basic concepts of market functions. • Build up vision towards how consumers makes choices and market reaches the equilibrium. • Develop decision making skill for firms about product selections and scale of production to ensure maximum profit. • Understand about different types of markets existing in the real world, their principles and whereabouts.

Suggested Reading

• Koutsoyiannis A. Modern Micro Economics. Macmillan Press LtdFerguson and Gould. Micro Economic Theory. Richard D Erwin Inc., USA • Richard A. Bilas, Micro Economic Theory. • Leftwich Richard H. The Price System and Resources Allocation • Allen CL. A Frame Work of Price Theory. 3

Course Title : Agricultural Production Economics

Course Code : AEC-502

Credit Hours : 1+1

Why this course?

Production in agriculture is the outcome of the input factors involved. In this competitive and uncertain market, it is important that the farmers take the right decision about the combination of inputs that will result in higher income. Thus, as an economist it is a pre-requisite that the students understand the interaction between output and input. And work out the most effective production plan.

Aim of the course

To expose the students to develop the concept, significance and uses of production economics. To understand the relationships between factors and

output. To learn how to decide the combination of inputs to be used as per the resources available. Ensure that the production process works efficiently.

Organization of the course

The course is organised as follows

No	Block	Unit
1.	Introduction to production economics	1. Concepts of production economics
2.	Factors and costs	1. Factors and theory of production
		2. Concepts of costs
3.	Assessment	1. Dynamics of assessment

Theory

Block 1: Introduction to Production Economics

Unit 1: Concepts of production economics

Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

Block 2: Factors and costs

Unit 1: Factors and theory of production

Factors of production, classification, interdependence, and factor substitution - Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

Unit 2: Concepts of cost Cost

functions and cost curves, components, and cost minimization -Duality theory– cost and production functions and its applications -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

Block 3: Assessment

Unit 1: Dynamics of economic assessment

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

Practical

• Different forms of production functions
• Specification, estimation and interpretation of production functions
• Returns to scale, factor shares, elasticity of production
• Physical optima-economic optima
• Least cost combination
• Optimal product choice
• Cost function estimation, interpretation
• Estimation of yield gap • Incorporation of technology in production functions
• Measuring returns to scale-risk analysis.

Teaching Methods/ Activities

• Lectures • Assignments (Group/individual)
• Group Discussions on working out
• Power point presentations by students
• Exploring the agricultural market and identification of industries and their type.

Learning outcome

After the successful completion of the course the student will be able to— Understand how the factors and output interact with each other. - Work out whether the production system is working efficiently and point out the loop holes.- Apply the knowledge of costs and profits to work out the demand and supply functions. This will result into more efficient decision making.

Suggested Reading

• EO Heady. Economics of Agricultural Production and resources use.
• John P Doll and Frank Orazem. Production Economics: Theory with application
• Heady EO & Dillon JL. 1961. Agricultural Production functions. Kalyani Publishers, Ludhiana, India. 667 p.
• Baumol WG. 1973. Economic theory and operations analysis. Practice Hall of India Private Limited, New Dehli.626 p.
• Gardner BL &Rausser GC. 2001. Handbook of Agricultural Economics Vol. I Agricultural Production. Elsevier.

Course Title : Agricultural Marketing and Price Analysis

Course Code : AEC 503

Credit Hours : 2+1

Why this course?

The ultimate aim of production process is to sell the produce in the market and generate income. Markets serves as platform where this exchange takes place. Agriculture markets are different from other markets due to the nature of the commodity. Thus, it is important to develop a strong foundation of agricultural marketing, its components and issues. The student needs to know about the multipronged ways of marketing the produce, agencies involved. In this modern era, it is important to understand how technology is transforming this sector.

Aim of the course

The course is designed to acquaint the students about the basics of dynamics of agricultural marketing. The content includes supply, demand and marketing of farm production, marketing functions and channels, marketing costs, margins and efficiency, agricultural prices, New marketing formats like e-marketing, e-NAM future trading, supply chain management, market intelligence etc.

Organization of the course The course is organised as follows:

No Block	Unit
1. Introduction to agricultural marketing	1. Introduction to agricultural marketing
2. Agricultural markets	1. Aspects of agricultural marketing 2. Future marketing and government
3. Advances in agricultural marketing	1. Use of information technology 2. Dynamics of price

Theory

Block 1: Introduction to Agricultural Marketing

Unit 1: Introduction to agricultural marketing

New Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical co-ordination.

Block 2: Agricultural Markets

Unit 1: Aspects of agricultural marketing

Different Forms of marketing: Co-operatives Marketing – APMC Regulated Marketing - Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, Organized retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies -Market infrastructure needs, performance and Government role - Value Chain Finance.

Unit 2: Future marketing and government

Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets – Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis – Role of Government/SEBI in promoting commodity trading and regulatory measures.

Block 3: Advances in Agricultural Marketing

Unit 1: Use of Information Technology

Role of Information Technology and Market Intelligence in marketing of agricultural commodities, -electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC).

Unit 2: Dynamics of price

Price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

Practical

• Supply and demand elasticities in relation to problems in agricultural marketing.
• Price spread and marketing efficiency analysis.
• Marketing structure analysis through concentration ratios.
• Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products.
• Supply Chain Analysis - quantitative estimation of supply chain efficiency.
• Market Intelligence – Characters, Accessibility, and Availability Price forecasting. • Online searches for market information sources and interpretation of market intelligence reports – commodity outlook.
• Technical Analysis for important agricultural commodities.
• Fundamental Analysis for important agricultural commodities.
• Presentation of the survey results and wrap-up discussion.

Teaching Methods/ Activities

• Lectures. • Case studies. • Assignments (Group/individual).

• Group Discussions on price volatility and control measures prevailing.
• Power point presentations by students on government schemes.
• Visit to eNAMmandies, Warehouses, etc.

Learning outcome

After the completion of this course the student will be able to–
• Understand the whereabouts of agricultural marketing.
• The different forms of marketing existing in this sector.
• Gain expertise in market intelligence and price forecasting.

Suggested Reading

• Acharya SS &Agarawal NL. 2004. Agricultural Marketing in India. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
• Acharya SS &Agarawal NL. 1994. Agricultural Prices-Analysis and Policy. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
• Richard H Kohls and Joseph N. Uhl: Marketing of Agricultural products by Collier MacMillan International.

Course Title : Macro Economics and Policy

Course Code : AEC-504

Credit Hours : 2+0

Why this course?

The economy of the nation is governed by certain rules, regulation and principles. The students has to gain knowledge of the mechanism through which the large economies are controlled and ensure that welfare prevails. They are entitled to know the transactions between different markets and policies framed to keep value of money under control.

Aim of the course

The course envisages the concepts and principles of macroeconomics from classical to Keynesian theories. The other component deals with the monetary systemmoney, credit and banking system, value of money and economic activities, national income accounting and approaches to estimate national income theory of income and employment determination and inflation.

Organization of the course

The course is organised as follows:

No Block	Unit

1. ConceptualisingMacro economics	1. Introduction: Measurement and Concepts
2. Theories of macroeconomics	1. Classical Macroeconomics 2. Income and spending: Keynesian Framework
3 Money, Consumption and Inflation	1. Money, Interest and Income 2. Theories of Aggregate Consumption and Investment 3. Inflation and Unemployment

Theory

Block 1: Conceptualising Macro Economics

Unit 1: Introduction: Measurement and Concepts

Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro-economic aggregates, relationship of national income and other aggregates (with numerical exercises), real and nominal income

Block 2: Theories of macroeconomics

Unit 1: Classical Macroeconomics

Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices.

Unit 2. Income And Spending: Keynesian Framework

Simple Keynesian model of income determination; Keynesian Multiplier-aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises).

Block 3- Money, Consumption and Inflation

Unit 1: Money, Interest and Income

Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference.Theory – Liquidity Trap; asset market equilibrium- LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy

Unit 2: Theories of Aggregarte Consumption and Investment

Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

Unit 3: Inflation and Unemployment Inflation: Nature, Effects and control; Types of inflation – demand pull, cost pushstagflation, core inflation, hyperinflation; Phillips curve.

Teaching Methods/ Activities

• Lectures. • Case studies.
• Assignments (Group/individual).
• Group Discussions on inflation.

Learning outcome

After the completion of the course the student will be able to-Understand the concepts of national income, theories build up to understand macroeconomics. Understand better about the policies and government steps taken to control the economic transaction of the nation. Workout how the investment acts as a catalyst in national development.

Suggested Reading

• Stonier &Hegue. A Text Book of Economic Theory
• Samuelson PA. 1948. Foundation of Economic Analysis. Harvard University Press
• MC VaishAllid. 1983. Macro–Economics Theory
• Gardner Ackley. 1961. Macro–Economics Theory: Macmillan, New York.
• TF Dernburg& DM Mcdougali-Macro Economics
• G. Sirkin – Introduction to Macro–Economics Theory
• RL Heibroker-Understanding Macro–Economics
• JK Mehta –Macro Economics
• Michael R Edgemand – Macro-Economics: Theory & Policy
• David' W Pearce –The dictionary of modern Economics

Course Title : Econometrics

Course Code : AEC 505

Credit Hours : 2+1

Why this course?

Development of analytical skills is imperative to make students proficient in conducting quality research work. The knowledge of variables, their models, and problems encountered when dealing with variables will build up a compatibility with the analytical aspects.

Aim of the course

• Testing and managing Multicollinearity
• Estimation of regressions with dummy variables

Teaching Methods/ Activities
• Lectures.
• Assignments (Group/individual).

Learning outcome
After the completion of the course, the student will be able to-Understand the variables and the properties of regression models. Identify the problems in variables and remove them before conducting the analysis and avoid biased results.

Suggested Reading
• Dorfman R. 1996. Linear Programming and Economic Analysis. McGraw Hill.
• Greene WH. 2002. Econometric Analysis. Pearson Education.
• Johnston J and Dinardo J. 2000. Econometric Methods. Mc Graw-Hill.
• Koutseyianis, A. 1997. Theory of Econometrics. Barner& Noble.
• Maddala GS. 2002. Econometrics. Mc Graw-Hill.
• Pinndyck RS and Rubinfeld DL. 1990. Econometric Models and Econometric Forecasts. McGraw Hill.

Course Title : Agricultural Finance and Project Management

Course Code : AEC 507

Credit Hours : 2+1

Why this course?
Money is the fuel of driving all the economic activities. India is a land of small and marginal farmers. The financial conditions of the farmers is not so strong that they can finance themselves. They require credit to meet the requirements of inputs. Thus, the student should know the sources, principles involved and types of credit available. The institutions involved and on what grounds the finance is given to the farmer. What are the risks involved and how to overcome them.

Aim of the course
This course is designed with an objective to deliver knowledge of the principles, procedures, problems and policies relating to financing agricultural

firms. In addition to this the students are also given knowledge about the research developments in the subject. The approach is analytic.

Organization of the course
The course is organised as follows:

No	Block	Unit
1	Introduction to Agricultural Finance	1. Basic Concepts: A review
2.	Credit and financial analysis	1. Credit and its aspects 2. Financial analysis
3	Project and risk management	1. Project Overview 2. Risk and its Management

Theory Block 1: Introduction to Agricultural Finance

Unit 1: Basic concepts: A Review

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

Block 2: Credit and Financial Analysis

Unit 1: Credit and its aspects

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

Unit 2: Financial analysis

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/ firm.

Block 3- Project and Risk Management

Unit 1: Project Overview Project

Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques –

Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques – PERT and CPM.

Unit 2: Risk and its Management

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes - yield loss and weather based insurance and their applications.

Practical

• Development of Rural Institutional Lending;

Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving;

• An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme;

• Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions;

• Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements;

• Performance of Micro Financing Institutions;

• NGO's and Self-Help Groups, Identification and formulation of investment projects;

• Project appraisal techniques – Undiscounted Measures and their limitations;

• Project appraisal techniques – Discounted Measures;

• Network techniques – PERT and CPM for project management;

• Case Study Analysis of an Agricultural project;

• Financial Risk and risk management strategies – crop insurance schemes;

• Financial instruments and methods – E banking, Kisan Cards and core banking.

IX. Teaching Methods/ Activities

• Lectures

• Case studies

• Assignments (Group/individual)

• Group Discussions on inflation

Learning outcome

After the completion of the course the student will be able to-Understand the key issues of finance in Agriculture. Learn the techniques of assessing the worth of a project.

Suggested Reading

• E Die Sollem H and Heady EO. (Ed.). Capital and Credit Needs in Changing Agriculture, Bauman.
• Hopkins A Barry, Peter Jo and Baker CB. Financial Management in Agriculture.
• Murray WG and Nelson AG. 1960. Agricultural Finance. Iowa State University
• Chanona C. 1969. Agricultural Finance in India: Role of Commercial Banks. Marketing and Economics Research Bureau, New Delhi.
• Gittinger JP. 1972. Economic analysis of agricultural projects, John Hopkins Univ. Press, Baltimore.
• Little IMD and JA Mirrless. 1974, Project appraisal and planning for developing countries, Oxford and IBH publishing Co. New Delhi.
• Arnold CH. 1972. Project Evaluation, collected papers, Macmillan.

Course Title : Linear Programming

Course Code : AEC-508

Credit Hours : 1+1

Theory

Unit I

Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

Unit II

Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

Unit III

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

Unit IV

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.

Practical

- Graphical and algebraic formulation of linear programming models.
- Solving of maximization and minimization problems by simplex method.
- Formulation of the simplex matrices for typical farm situations.

Course Title : Research Methodology for Social Sciences

Course Code : AEC 509

Credit Hours : 1+1

Why this course

Planning of research is very crucial to conduct a successful research. There is need to give an insight to the student about how to conduct a research, right from data collection to analysis and finally writing the references.

Aim of the course

The course deals with scientific methods of research, the initiation of an inquiry, formulation of research problems and hypotheses, the role of induction and deduction in research, collection and analysis of date and interpretation of results

Organization of the course

The course is organised as follows:

No Block	Unit
1. Introduction to research methodology	1. Concepts of research methodology
2. Building up hypothesis and sample selection	1. Hypothesis: Framing and Testing 2. Sampling
3. Data collection and analysis	1. Data collection 2. Data Analysis

Theory

Block 1: Concepts of research methodology

Unit 1: Concepts of research methodology

Importance and scope of research in agricultural economics. Types of research – Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

Block 2- Building up hypothesis and sample selection

Unit 1: Hypothesis: Framing and Testing

Hypothesis – meaning – characteristics – types of hypothesis – review of literature – setting of Course Objective and hypotheses – testing of hypothesis.

Unit 2: Sampling

Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques – Types of research design.

Block 3- Data Collection and Analysis

Unit 1: Data Collection

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.

Unit 2: Data Analysis

Data coding, tabulation, cleaning. –Multivariate analysis –factor analysis' PCA' cluster analysis. Universal procedures for preparation of bibliography – writing of research articles.

Practical

- Exercises in problem identification.
- Project proposals – contents and scope.
- Formulation of Objective and hypotheses.
- Assessment of data needs – sources of data – methods of collection of data.
- Methods of sampling – criteria to choose – discussion on sampling under different situations.
- Scaling Techniques – measurement of scales.
- Preparation of interview schedule.
- Field testing. Method of conducting survey.
- Exercise on coding, editing, tabulation and validation of data.
- Preparing for data entry into computer.
- Hypothesis testing – Parametric and Non-Parametric Tests.
- Exercises on format for Thesis/ Report writing.
- Presentation of the results.

IX. Teaching Methods/ Activities

• Lectures. • Case studies.
• Assignments (Group/individual).
• Group Discussions

Learning outcome

After the successful completion of this course, student will be able to- Understand fundamentals of research. How to carefully plan out the research work and conduct it.

Suggested Reading

• Baker CB. Research Methodology in Agricultural Economics
• Cohen MR and Nagel R. An Introduction to Logic and Scientific Method
• Devey J Logic. The Theory of Enquiry
• Dhondhyal SP. Social Science Research and Thesis Writing
• Ezekiel M. Correlation Analysis
• Heady EO. Linear Programming Methods
• Willson ER. An Introduction to Scientific Research
• Kumar A. 2008. Research Methodology: A Survey. Alts, New Delhi,

Teaching methods

• Power point presentation

• Chalk and Board • Smart board

• Lectures • Assignments, quiz

• Group tasks, student's presentations

Learning outcome

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Suggested reading

Daniel LH and Maryellen R. 2011. Genetics: "Analysis of Genes and Genomes". Gardner EJ and Snustad DP. 1991. Principles of Genetics. John Wiley and Sons. 8th ed. 2006 Klug WS and Cummings MR. 2003. Concepts of Genetics. Peterson Edu. Pearson Education India; Tenth edition Lewin B. 2008. Genes XII. Jones and Bartlett Publ. (International Edition) Paperback, 2018 Russell PJ. 1998. Genetics. The Benzamin/ Cummings Publ. Co Singh BD. 2009. Genetics. Kalyani Publishers (2nd Revised Edition) Snustad DP and Simmons MJ. 2006. Genetics. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition Stansfield WD.1991. Genetics.Schaum Outline Series Mc Graw Hill Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India; 3rd ed., 2015 Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs., McGraw Hill Education; 7 edition Uppal S, Yadav R, Singh S and Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

Course Title : Principles of Plant Breeding*

Course Code : GPB 502

Credit Hours : 3(2+1)

Why this course?

Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour. Plant Sciences–Genetics and Plant Breeding

Aim of the course

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Theory

Unit I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

Unit II

Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny

selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

• Floral biology in self and cross pollinated species;

• Selfing and crossing techniques;

• Selection methods in segregating populations and evaluation of breeding material;

• Analysis of variance (ANOVA);

• Estimation of heritability and genetic advance;

• Maintenance of experimental records;

• Learning techniques in hybrid seed production using male-sterility in field crops;

• Prediction of performance of double cross hybrid.

Teaching methods

• Power point presentation

• Chalk and Board

• Smart board

• Lectures

• Assignments, quiz

• Group tasks, student's presentations

Learning outcome

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, etc.

Suggested Reading

Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons. Chahal GS and Gossal, SS. 2002. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House. Chopra VL. 2004. Plant Breeding. Oxford & IBH. George A. 2012. Principles of Plant Genetics and Breeding. John Wiley & Sons. Gupta SK. 2005. Practical Plant Breeding. Agribios. Jain HK and Kharakwal MC. 2004. Plant Breeding and–Mendelian to Molecular Approach, Narosa Publications, New Delhi Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill. Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi. Simmonds NW.1990. Principles of Crop Improvement. English Language Book Society. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi. Singh S and Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

Course Title : Fundamentals of Quantitative Genetics*

Course Code : GPB 503

Credit Hours : 3 (2+1)

Why this course?

Yield and quality characters are controlled by many genes and show the quantitative inheritance. If one has to go for improvement even for the components characters the knowledge of this course is very essential.

Aim of the course

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effects.

Theory

Unit I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysisMetroglyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action, G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models-principles and interpretation, Bi-plot analysis. Unit V QTL mapping, Strategies

for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

Practical

• Analysis and interpretation of variability parameters;

• Analysis and interpretation of Index score and Metroglyph;

• Clustering and interpretation of D2 analysis;

• Genotypic and phenotypic correlation analysis and interpretation;

• Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;

• A, B and C Scaling test;

• L × T analysis and interpretation, QTL analysis;

• Use of computer packages; • Diallel analysis;

• G × E interaction and stability analysis.

Teaching methods

• Power point presentation

• Chalk and Board

• Smart board • Lectures,

• Assignments, quiz

• Group tasks, student's presentations

Learning outcome

After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

Suggested Reading

Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall. Falconer DS and Mackay J. 1998. Introduction to Quantitative Genetics

(3rd Ed.).ELBS/ Longman, London. Mather K and Jinks JL.1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London. Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi. Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi. Roy D. 2000. Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi. Sharma JR. 2006. Statistical and Biometrical Techniques in Plant Breeding. New Age International Pvt. Ltd. Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi. Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis. Kalyani Publishers, New Delhi. Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates. Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter. e-Suggested Reading www.iasri.icar.gov.in www.hau.ac.in/OPstat

Course Title : Varietal Development and Maintenance Breeding

Course Code : GPB 504

Credit Hours : 2(1+1)

Why this course?

It is an indispensable course which apprise the students about various practices and procedures in the development of a variety and steps to maintain the purity of varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

Aim of the course

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

Theory

Unit I

Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Unit III

Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit IV

Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V

Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

Practical

• Identification of suitable areas/ locations for seed production;

• Ear-to-row method and nucleus seed production;

• Main characteristics of released and notified varieties, hybrids and parental lines;

• PGMS and TGMS;

• Identification of important weeds/ objectionable weeds;

• Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops;

• Hybrid seed production technology of important crops;

• DUS testing and descriptors in major crops;

• Variety release proposal formats in different crops.

Teaching methods

• Power point presentation

• Chalk and Board • Smart board

• Lectures • Assignments, quiz

• Group tasks, student's presentations

Learning outcome

Pass out student will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

Suggested Reading

Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH. Kelly AF. 1988. Seed Production of Agricultural Crops. Longman. McDonald MB Jr and Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall. Poehlman JM and Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH. Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani. 2015 Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill

Course Title : Principles of Cytogenetics

Suggested Reading

Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London. Chadwick KH and Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. SpringerVerlag. Cotton R, Edkin E and Forrest S. 2000. Mutation Detection: A Practical Approach. Oxford Univ. Press. International Atomic Energy Agency. 1970. Manual on Mutation Breeding. International Atomic Energey Agency, Vienna, Italy. Shu QY, Forster BP and Nakagawa N. 2012. Plant Mutation Breeding and Biotechnology. Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO). Singh BD. 2003. Genetics. Kalyani Publishers, New Delhi. Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall. www.barc.gov.in

Course Title : Breeding for Stress Resistance and Climate Change

Course Code : GPB 516

Credit Hours : 3(2+1)

Why this course?

Climate change is a big challenge to sustain higher crop productivity and nutritional quality. Concept of breeding for stress tolerance and development of hybrids/ varieties for climate change is of prime importance in plant breeding. Therefore this course is essential for budding plant breeders.

Aim of the course

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

Theory

Unit I

Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops.

Unit II

Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications. Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/ low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Unit V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses,

use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

Practical

• Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria;

• Symptoms and data recording; use of MAS procedures;

• Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level;

• Phenotypic screening techniques for nematodes and borers; Ways of combating them;

• Evaluating the available populations like RIL, NIL, etc. for pest resistance;

• Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops;

• Breeding for herbicide resistance;

• Screening crops for drought and flood resistance; factors to be considered and breeding strategies;

• Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies;

• Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

Teaching methods

• Power point presentation

• Chalk and Board

• Smart board

• Lectures

• Assignments, quiz

• Group tasks, student's presentations

Learning outcome

After completion of this course the student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL, etc. for pest resistance and Use of standard MAS procedures

Suggested Reading

Blum A. 1988. Plant Breeding for Stress Environments. CRC Press. Christiansen MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International. Fritz RS and Simms EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press. Li PH and Sakai A. 1987. Plant Cold Hardiness. Liss, New York Springer Luginpill P. 1969. Developing Resistant Plants - The Ideal Method of Controlling Insects. USDA, ARS, Washington DC. Maxwell FG and Jennings PR. (Eds.). 1980. Breeding Plants Resistant to Insects. John Wiley & Sons. Wiley-Blackwell. Roberto F. 2018. Plant Breeding for Biotic and Abiotic Stress Tolerance. Springer. Russel GE. 1978. Plant Breeding for Pest and Disease Resistance. Butterworths. Sakai A and Larcher W. 1987. Frost Survival in Plants. Springer-Verlag. Plant Sciences–Genetics and Plant Breeding 39 Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi. Turener NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons. van der Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

Note: For minor courses please refer the concerned department's courses outline

• Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera;
• Field visits to collect insects of different orders.

Learning outcome

• Students are expected to know the evolution of arthropods, especially insects and other hexapods, and their hierarchical classification
• Acquire working skills for collecting, mounting, and preserving insects
• Understand the basic concepts of taxonomic hierarchy, identification, taxonomic characters, variations, taxonomic keys and preparation of taxonomic papers
• Identify insects of economic importance up to family levels, taking up the insect orders of agriculture and veterinary importance

Suggested Reading

CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca. Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi. Gullan PJ and Cranston PS. 2010. The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK. Mayr E. 1971. Principles of Systematic Zoology. Tata McGraw Hill, New Delhi. Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London. Ross HH.1974. Biological Systematics. Addison Wesley Publ. Company. Triplehorn CA and Johnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.

Course Title : Biological Control of Insect Pests And Weeds

Course Code : ENT 505

Credit Hours : 3 (2+1)

Aim of the course

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

Unit I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control-importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

Unit II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit III

Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.

Unit IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

• Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers;

• Visits to bio-control laboratories to learn rearing and mass production of egg, egglarval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;

• Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Learning outcome

• Students are expected to have a good understanding of the role of natural enemies in managing pest populations below those causing economic damage

• Learn the techniques for mass production of quality bio-agents and their optimal use in IPM

Suggested Reading

Burges HD and Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London. De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, New York. Dhaliwal GS and Arora R. 2001. Integrated Pest Management: Concepts and Approaches. Kalyani Publishers, New Delhi. Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman and Hall, New York. Huffaker CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London. Ignacimuthu SS and Jayaraj S. 2003. Biological Control of Insect Pests. Phoenix Publ., New Delhi. Saxena AB. 2003. Biological Control of Insect Pests. Anmol Publ., New Delhi. Van Driesche and Bellows TS. Jr. 1996. Biological Control. Chapman and Hall, New York.

Course Title : Toxicology of Insecticides

Course Code : ENT 506

Credit Hours : 3 (2+1)

Aim of the course

To orient the students with structure and mode of action of important insecticidesbelonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

Unit I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit II

Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

Unit III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticidessynergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

Unit IV

Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

Unit V

Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

- Insecticide formulations and mixtures;
- Laboratory and field evaluation of bio-efficacy of insecticides;
- Bioassay techniques;
- Probit analysis;
- Evaluation of insecticide toxicity;
- Toxicity to beneficial insects;
- Pesticide appliances;
- Working out doses and concentrations of pesticides;
- Procedures of residue analysis.

Learning outcome

• Students are expected understand the concept of toxicity, bio-efficacy, insecticide formulations, modes of action of insecticides, estimation of insecticide residues and have significant know-how about the functioning of various types of spray equipments.

Suggested Reading

Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.Dodia DA, Petel IS and Petal GM. 2008. Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur. Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA Gupta HCL.1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur. Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.

Ishaaya I and Degheele D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi. Krieger RI. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida. Mathews GA. 2002. Pesticide Application Methods. 4th Ed. Intercept. UK. Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York. Otto D and Weber B. 1991. Insecticides: Mechanism of Action and Resistance. Intercept Ltd., UK. Pedigo LP and Marlin ER. 2009. Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A. Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi. Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publication, New York. Roy NK. 2006. Chemistry of Pesticides. Asia Printograph Shahdara Delhi.

Course Title : Concepts of Integrated Pest Management

Course Code : ENT 508

Credit Hours : 2 (2+0)

Aim of the course

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL and implementing IPM programmes.

Theory

Unit I

History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.

Unit II

Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Unit III

Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; costbenefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Unit IV

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Learning outcome

• Students are expected to have significant knowledge of IPM concepts, estimation of losses due to insect pests, computation of ETL, EIL and should be able take management decisions.

Suggested Reading

Dhaliwal GS and Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publishers, New Delhi. Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi. Ignacimuthu SS and Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi. Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi. Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi. Subramanyam B and Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

Course Title : Pests of Field Crops

Course Code : ENT 509

Credit Hours : 3 (2+1)

Aim of the course

AGRICULTURAL EXTENSION EDUCATION

Course Title : Extension Landscape

Course Code : EXT 501

Credit Hours : 2+0

Why this course?

Extension and advisory services (EAS) need to support farmers to deal with several new challenges they face currently. To effectively support farmers, EAS should perform several new functions and it should have capacities to perform these functions. EAS have evolved considerably especially during the last 3 decades. Several new approaches have emerged and many new funding and delivery models emerged in response to reforms (economic policies and new governance structure) implemented in several countries. Apart from these, new insights from communication and innovation studies have also started to influence the practice of extension. There is a lot of interest globally in strengthening pluralistic EAS and enhancing its contribution towards development of an effective Agricultural Innovation System (AIS). Keeping these in view, there is a need to orient students of extension on how extension is shaped globally and the policy level challenges it faces so that the extension students fit well to the global demand for competent extension professionals who can appreciate and understand this changing context.

Aim of the course

The aim of this course is to introduce the new challenges before extension and how extension is evolving globally. It presents the new capacities that are needed by EAS providers to provide a much wider support to farmers and it orient students to the new insights from communication and innovation studies that are influencing the practice of extension globally. The course also help students to appreciate the process and the impact of extension reforms implemented in many countries, the new approaches that are evolving globally in different regions and the policy challenges in managing a pluralistic extension system. The course is organized as follows:

No	Blocks	Units
1	Globally,What is new in Extension?	1. Challenges Before Extension and Advisory Services

	2. New Functions and New Capacities 3. Pluralism in EAS
2. Insights from Communication & Innovation Studies & New Extension Approaches 3 Extension Reforms And Policy Challenges	1. From the Linear Paradigm To Systems Paradigm 2.Evolving Extension Approaches 1.Changes In Governance, Funding and Delivery of EAS 2. Challenges In Managing Pluralistic EA

Learning outcome

After successful completion of this course, the students are expected to be able to:

– Appreciate the changing global extension landscape

– Broaden their understanding on the role of EAS in agricultural innovation system

– Critically evaluate the reforms in extension and the evolving approaches in extension

– Analyse the policy level challenges in extension funding and delivery

Block 1: Globally, What Is New In Extension?

Unit 1:Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management-Supporting farmers to manage the declining/deteriorating water and soil for farming; Gender Mainstreaming-How extension can enhance access to new knowledge among women farmers; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Adaptation to climate changes-How extension can contribute to up-

scaling Climate Smart Agriculture; Supporting family farmsstrengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urban agriculture; Farmer distress, suicides- Supporting farmers in tackling farm distress.

Unit 2: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/ innovation platforms.

New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; –Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

Unit 3:

Pluralism in EAS Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/international)/ Civil Society Organizations (CSOs) in providing extensionExperiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength andweaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision.

This course will equip the students to become potential change agents and OD practitioners. They should be able to learn how to improve individual, group/team and organizational performance through the use of OD techniques or interventions.

Suggested Reading

Bhattacharyya DK. 2011. Organizational Change and Development, Oxford University Press. Hellriegel D, Sloccum JW and Woodman. 2001. Organizational Behaviour. Cincinnati, Ohio: South-Western College Pub. Luthans F. 2002. Organizational Behaviour. Tata McGraw-Hill, New York Newstrom JW and Davis K. 2002. Organizational Behaviour: Human behaviour at Work. TataMcGraw Hill, New Delhi. Peter MS. 1998. The Fifth Discipline: The Art and Practice of Learning Organization. Random House, London. Pradip NK. 1992. Organizational Designs for Excellence. Tata McGraw Hill, New Delhi. Shukla, Madhukar. 1996. Understanding Organizations. Prentice Hall of India, New Delhi. Stephens PR and Timothy AJ. 2006. Organizational Behaviour, 12th Edition. Prentice Hall Pub. Thomas GC and Christopher GW. 2013. Organizational development and change, 10th edition, South-Western college publishing. Wendell LF and Cecil HB. 1999. Organizational Development: Behavioural science interventions for organization improvement, Pearson. 368 pp.

Course Title : Research Methodology in Extension

Course Code : EXT 504

Credit Hours : 2+1

Why this course?

Growth of any discipline is directly proportional to the creation of knowledge in that discipline. Extension research is the backbone of extension discipline. Extension research is a unique social science inquiry where research ideas are gathered from the field problems and put through a systematic cycle of objective investigations that result in significant solutions. Apart from developing theories and models that advance scientific knowledge, extension research should also provide new insights for improving extension policy and practice. As extension is a field oriented discipline seeking to improve the welfare of its stakeholders, the extension professionals require critical

competencies in conducting empirical research for developing sound extension models, methods and tools.

Aim of the course

This course aimed to create a workforce which has sound fundamental knowledgeand critical competencies in planning, conducting and applying behavioural research for developing quality extension models, methods and tools.

The course is organized as follows:

No. Blocks	Units
1. Introduction to behavioural	1.Nature of Behavioural Research research 2. The Behavioural Research Process
2. Steps in behavioural research	1.Formulating a Research Problem process 2. Reviewing the Literature 3. Identifying Variables and Hypotheses 4.Formulating Research Designs, Methods and Tools 5. Selecting Sample 6. Collecting Data 7. Analysing and Interpreting the Data 8. Reporting and Evaluating Research

Theory

Block 1: Introduction To Behavioural Research

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

Block 2: Steps in Behavioural Research Process

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literatureand writing literature review.

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables –causal relationship, the study design; and the unit of measurement; Types of definitions-Types of propositions and hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies, Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulation. Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales – scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Sampling with or without replacement, Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Nonprobability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalisation – Importance, Types of generalisations.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity, factorial validity, and nomological validity; Types of reliability – Test-Retest, Parallel forms, Inter-

item consistency reliability, Split-half reliability, factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing - Effect Size, á, â, and Power, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology

Practicals

• Selecting a research problem and writing problem statement

• Narrowing down research problem to purpose, research questions and objectives

• Choosing, evaluating and reviewing research literature

• Selection of variables through construct conceptualisation and defining variables

• Choosing research design based on research problem

• Choosing right sampling method and estimating sample size

• Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides

• Writing a research proposal

• Field data collection using research methods and tools

• Testing reliability and validity of research instruments

• Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research

• Writing report, writing of thesis and research articles

• Presentation of reports

Teaching methods/activities

– Lecture cum discussion
– Class exercises
– Assignment(Reading/Writing)
– Student's Book/Publication Review
– Student presentation
– Group Work
– Research Report

Learning outcome

– Understand the concepts, paradigms, approaches and strategies of behavioural research
– Enable to choose research design, methods and tools suitable for the research problem
– Design research instruments skilfully and conduct research in an objective and unbiased way
– Analyse the data through appropriate analytical methods and tools and derive meaningful interpretations

Suggested Reading

Babbie E. 2008. The basics of social research. 4th ed. Belmont, CA, USA; Thompson Wordsworth. Creswell JW. 2009. Research design: Qualitative, quantitative, and mixed methods approaches. Third edition. Thousand Oaks: Sage Publications. Creswell JW. 2012. Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Fourth edition. Boston, MA: Pearson. Kerlinger FN and Lee HB. 2000. Foundations of Behavioral Research. Orlando, FL: Harcourt College Publishers. Kumar R. 2014. Research Methodology: A Step- by- Step Guide for Beginners. Fourth. Edition. Thousand Oaks, California: Sage Publications. Malhotra NK. 2010. Marketing research: An applied orientation. Sixth Edition. Upper Saddle River, NJ: Prentice Hall. NeumanWL. 2006. Social Research Methods: Qualitative

and Quantitative Approaches. Toronto: Pearson. Sekaran U and Bougie R. 2013. Research Methods for Business A Skill-Building Approach. 6th Edition, Wiley, New York. Sendhil R, Kumar A, Singh S, Verma A, Venkatesh K and Gupta V. 2017. Data Analysis Tools and Approaches (DATA) in Agricultural Sciences. e-Compendium of Training-cumWorkshoporganised at the ICAR-IIWBR during March 22-24, 2017. pp 1-126. Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. Good Practices in Agricultural extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia. Centre for Research on Innovation and Science and Policy (CRISP), Hyderabad. India. Sivakumar PS and Sulaiman RV. 2015. Extension Research in India-Current Status and Future Strategies. AESA Working Paper 2. Agricultural Extension in South Asia.http:// www.aesanetwork.org/aesa-working-paper-2-on-extension-research-in-india-currentstatus-and-future-strategies-p-sethurman-sivakumar-and-rasheed-sulaiman-v-december2015/

Course Title : Capacity Development

Course Code : EXT 505

Credit Hours : 2+1

Why this course?

Competent and skilful extension professionals are not naturally born. Their capacities need to be improved primarily at three different levels:

1. Pre-service capacity development – Under graduation and post-graduation studies
2. Induction capacity development – Just before job entry
3. In-service capacity development – During job

If undergone appropriately, pre-service studies help extension professionals to mainly acquire knowledge related to development. However, they are not fully ready for development work with required attitude and skills needed by an organisation. Properly planned and organized induction / in-service capacity building programmes help them to use development concepts, apply methods, exhibit attitude and skills required for development work at different levels. In short, the essence of this course is to make you understand these notions and help you to think up, manage, put into practice and evaluate capacity development programmes.

Aim of the course

• To understand the concepts of training, capacity building, capacity development and human resource development in the context of roles and responsibilities of extension professionals

• To discuss capacity development- approaches, strategies, needs assessment and methods / tolls

• To help you devise, organize, implement and evaluate capacity development programmes The course is organized as follows:

No Blocks	Units
1. Introduction to Capacity Development	1. Capacity Development - An Overview 2. Capacity Development - Approaches and Strategies 3. Planning and Organization of Capacity Development Programmes
2. Capacity Development Needs	1. Capacity Development Needs Assessment - Assessment An Overview 2. Capacity Development Needs Assessment Methods
3.Capacity Development Institutions and Management	1. Capacity Development Institutions 2.Capacity Development Project Formulation
4. Capacity Development Process and HRD	1.Capacity Development Methods and Tools 2. Evaluation 3. Impact Assessment 4. Human Resource Development

Theory

Block 1: Introduction to Capacity Development

Unit 1: Capacity Development–An Overview

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities (include the rules, regulations and practices

that set the overarching contextual environment), Organisational capacities (how various actors come together to perform given tasks), Individual capacities (technical, functional and leadership skills). Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.). Components of capacity development; Capacity development cycle.

Unit 2: Capacity Development- Approaches and Strategies

Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development -Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

Unit 3: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step 7. Prepare evaluation form, Step 8. Determine follow-up activities; Organising capacity development programme; Operational arrangements at different stages- Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

Block 2: Capacity Development Needs Assessment

Unit 1: Planning and Organization of Capacity Development Programmes

Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group

Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, Gap Analysis.

Block 3: Capacity Development Institutions and Management

Unit 1: Capacity Development Institutions

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, ad-hoc, part time, guest and consultants); Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/ interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA).

Block 4: Capacity Development Process and HRD

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group/ Laboratory methods; Factors Determining Selection of Methods - Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity Development Aids.

Unit 2: Evaluation

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation; Process of Evaluation- Evaluation at the beginning, Evaluation during the programme,

Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 3: Impact Assessment

Impact Assessment- Meaning, Need, Features, Benefits, Concepts; Indicators for Impact Assessment - Direct indicators, Indirect or proxy indicators, Quantitative indicators, Qualitative indicators, Result chain / hierarchy of indicators; Methods of Impact Evaluation- Learning retention of participants (KOSA), Impact on the job performance, Impact on organizational effectiveness, Impact on stakeholder's competency.

Unit 4: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Work system (Role analysis, Role efficacy, Performance plan, Performance feedback and guidance, Performance appraisal, Promotion, Job rotation, Reward), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counselling, Mentor system), Self-renewal system (Survey, Action research, Organisational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small groups); Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialisation System, Governance; Functions of HRD-Organisational Development, Career Development, Capacity Development.

Practicals

- Capacity development needs assessment exercise
- Capacity development project formulation exercise
- Planning organizing and conducting an extension capacity development programme
- Designing a programme
- Writing learning objectives
- Developing objectives into curriculum

• Training plan

• Organizing capacity development workshop

• Evaluation with pre- and post-training tests

• Training methods – Practicing each method mentioned in contents as group exercise

Teaching methods/activities

– Lecture – Assignment (Reading/Writing)

– Student's Book/Publication Review

– Student presentation

– Group work

– Case Analysis

– Guest Lectures

– Review of training manuals and training evaluation studies

– Short attachments to a nearby training institute.

Learning outcome

After successful completion of this course, the students are expected to be able to: – Differentiate between training, capacity building, capacity development and human resource development – Explain different levels of capacities, needs assessment approaches & methods, capacity development methods and tools – Formulate, implement and evaluate need based capacity development programmes

Suggested Reading

ADB. 2009. Training Needs Assessment and Strategic Training Plan. Bentaya GM, and Hoffmann V (Eds). 2011. Rural Extension Volume 3 -Training Concepts and Tools. Margraf Publishers GmbH, Scientific books, KanalstraBe 21; D-97990, Weikersheim, 191 pp. DFID .2003. Promoting Institutional and Organisational Development. A Source Book of Tools and Techniques, Department for International Development, United Kingdom DoPT.2014. Civil Services Competency Dictionary: Strengthening Human Resource Management of Civil Service. Department of Personnel and Training,

Course Title : ICTs for Agricultural Extension and Advisory Services

Course Code : EXT 506

Credit Hours : 2+1

Why this course?

Information and Communication Technologies (ICTs) are continuously evolving. More ICT applications having better relevance to extension and advisory services (EAS) are currently available considering the human and other resource constrains faced by EAS, ICTs can supplement and complement EAS extension efforts in a cost-effective way. Extension professionals should have sound knowledge of ICTs and comprehensive understanding on its various applications for effectively deploying these in EAS provision. This course will provide knowledge and hands-on-experience on ICT applications relevant for EAS.

Aim of the course

• To discuss different ICT initiatives, knowledge management process and application aspects

• To orient students on advances in smart/ disruptive technologies and data analytics

• Hands on experience in navigating ICTs The course is organized as follows:

No	Blocks	Units
1.	Introduction to Information and Communication Technologies (ICTS) and e-Extension	1.ICTs- Concepts and Status 2.ICTs in Knowledge Management 3.e-Extension initiatives in Agriculture and allied sectors
2.	Application of ICTs in Extension and advisory services	1. ICT Applications 2. ICT Expert Systems 3. ICT Networks
3.	Knowledge management and Standards	1. Policies in Knowledge Management 2. Web Standards

	3. Social Media Applications to engage audience
4.Smart and disruptive Technologies and advanced analytics for agricultural extension	1. Smart Technologies 2. Human Computer Interactions

Theory

Block 1: Introduction to Information and Communication Technologies (ICTs) and E-extension

Unit 1: ICTs- Concepts and Status

ICTs- meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, e-learning, mLearning, advantages and limitations of ICTs.

Unit 2: ICTs in Knowledge Management

Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 3: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview on Global and national e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.

Block 2: Application of ICTs in Extension and Advisory Services

Unit 1: ICT Applications

Knowledge centres (tele centres), digital kiosks, websites and web portals, community radio, farmers call centres, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains and Value-Chains/ e-Marketing (e-NAM, Agmarknet, etc.).

Unit 2: ICT Expert Systems

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, etc.

Unit 3: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CCRA, EduEx, etc), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organisations (FPOs)/ SHGs/ Farmers Groups.

Block 3: Knowledge Management and Standards

Unit 1: Policies in Knowledge Management

Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.

Unit 2: Web Standards

Web standards, creating and writing for webportals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.

Unit 3: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

Block 4: Smart and Disruptive Technologies and Advanced Analytics for Agricultural Extension

Unit 1: Smart Technologies

Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Unit 2: Human Computer Interactions

Human Centered Learning/Ergonomics/ Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, van Merriënboer's four-component instructional design model for multimedia learning; Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Advanced principles - Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory. Designing ICT gadgets based on human interaction principles - Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activitycentered design, systems design, and genius design; Methods of interactive design - Usability testing methods.

Practicals

• Content and client engagement analysis

• Designing extension content for ICTs

• Creating and designing web portals, blogs, social media pages

• Developing digital videos

Live streaming extension programmes and organising webinars

• Working with Farmers call centres

• Engaging with professional digital networks • Writing for digital media

Teaching methods/activities

– Lecture

– Guest Lectures

–Assignment (Reading/Writing/ developing mApps/ media management/Social media initiatives)

– Student's Book/Publication Review

– Student presentation

– Group Work

– Student's interview of ICT practitioners/ champions

– Documenting good practices and case studies

– Review of ICT policy documents and guidelines/ standards

– Short internship with ICT projects

Learning outcome

After successful completion of this course, the students are expected to be able to:

– Appreciate the importance of the ICTs in EAS

– Understand the ICT application aspects

– Critically evaluate ICT initiatives and smart/disruptive technologies

– To execute extension functions by applying ICTs and

– Engage stakeholders in knowledge management process

Suggested Reading

Andres D and Woodard J. 2013. Social media handbook for agricultural development practitioners. Publication by FHI360 of USAID. http://ictforag.org/toolkits/ social/ SocialMedia4 AgHandbook.pdf Barber J, Mangnus E and Bitzer V. 2016. Harnessing ICT for agricultural extension. KIT Working Paper 2016: 4. https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/ 2/2016/11/KIT_WP2016-4_Harnessing-ICT-for-agricultural-extension.pdf Bheenick K and Bionyi I. 2017. Effective Tools for Knowledge Management and Learning in Agriculture and Rural Development. CTA Working paper. https://publications.cta.int/media/publications/downloads/1986_PDF.pdf Fafchamps M and Minten B. 2012. Impact of SMS based Agricultural Information on Indian Farmers. The World Bank Economic Review, Published by the Oxford University Press on behalf of the International Bank for Reconstruction and Development. FAO 2011. E-learning methodologies a guide for designing and developing e-learning courses. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/015/i2516e/i2516e.pdf George T, Bagazonzya H, BallantyneP, Belden C, Birner R, Del CR and Treinen S. 2017. ICT in

publications.html? download=414: social-mediashaping-the-future-of-agricultural-extension-and-advisory-services Vignare K. 2013. Options and strategies for information and communication technologies within agricultural extension and advisory services. MEAS Discussion paper. http://meas.illinois.edu/wpcontent/uploads/2015/04/Vignare-K-2013-ICT-and-ExtensionMEAS-Discussion-Paper.pdf World Bank. 2017. ICT in Agriculture (Updated Edition): Connecting Smallholders to Knowledge, Networks, and Institutions. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/27526 Websites FAO–Food and Agricultural Organisation (Research and Extension) http://www.fao.org/research-and-extension/en/ CTA–The Technical Centre for Agricultural and Rural Cooperation: Digitalization–https://www.cta.int/en/channel/digitalisation-sid05951b8c7-e611-4f34-9ae6-8c0fc0c822bc GFRAS–Global Forum for Rural Advisory Services–http://www.g-fras.org/en/ AESA–Agricultural Extension in South Asia–http://www.aesanetwork.org/

Course Title : Evaluation and Impact Assessment

Course Code : EXT 507

Credit Hours : 2+1

Why this course?

Many organizations now look for experts to evaluate development projects and developmental interventions. It is now required that impact be assessed whenever any development programme is implemented. Thus, the extension professionals need to have good understanding of the theory and practice of programme evaluation and impact assessment. This course, thus, has been designed to help students develop as extension professionals who can plan and conduct systematic assessments of the results and impacts of extension programmes.

Aim of the course

• To orient students on the importance of evaluation and impact assessment

• To develop capacities for evaluation and impact assessment

• Discuss ways of conducting evaluations and impact assessment

The course is organized as follows:

No Blocks	Units
1. Programme Evaluation	1. Introduction to Evaluation
	2. Evaluation Theories
2. Evaluation Process	1. How to Conduct Evaluation
	2. Evaluating the Evaluation
3. Programme Management Techniques	1. SWOT Analysis and Bar Charts
	2. Networks
4. Programme Evaluation Tools	1. Bennett's Hierarchy of Evaluation
	2. Logic Framework Approach
5. Impact Assessment	1. Introduction to Impact Assessment
	2. Impact Assessment Indicators
	3. Approaches to Impact Assessment

Theory

Block 1: Programme Evaluation

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, analyseprogramme effectiveness, decision making, accountability, impact assessment, policy advocacy; Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the context of program evaluation in agricultural extension; Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice – synergistic role between practice and theory in evaluation; Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories/ approaches - Utilization-Focused Evaluation

& Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). Integration between theory and practice of evaluation: –evaluation forums, workshops, conferences and apprenticeship/ internship.

Block 2: Evaluation Process

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, ongoing, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyse and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

Unit 2: Evaluating the Evaluation

Evaluating the Evaluation - 10 Steps as above with focus on conceptual clarity,representation of programme components and stakeholders, sensitivity, representativeness of needs, sample and data, technical adequacy, methods used for data collection and analysis, costs, recommendations and reports.

Block 3: Programme Management Techniques

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations.

Unit 2: Networks

Networks – Introduction, origin and widely used networks Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (To), Pessimistic time (Po), Most likely time (TM), Expected time (TE), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation with example.

Block 4: Programme Evaluation Tools

Unit 1: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy

Unit 2: Logic Framework Approach (LFA)

Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by-Four Grid – Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) where information will be available on the OVIs, and Assumptions). Advantages and Disadvantages of LFA.

Block 5: Impact Assessment

Unit 1: Introduction to Impact Assessment

Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient, etc). Qualitative and Participatory Impact Assessment Methods.

Unit 4: Environment Impact Assessment (EIA)

Concept of EIA – Introduction, What it is? Who does it? Why it is conducted? How it is done?; Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring. Environmental Components of EIA – air, noise, water, biological, land; Composition of the expert committees and Steps in EIA process - screening, scoping, collection of baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, assessment of alternatives, delineation of mitigation measures and EIA report; Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?

Practicals

• Search the literature using web / printed resources and identify evaluation indicators for the following:

– Utilization-Focused Evaluation

– Values Engaged Evaluation

– Empowerment Evaluation

– Theory-Driven Evaluation

• Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theory class.

• Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.

• Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.

• Identify an on-going development programme and make-out 6 activities from the programme. • Draw a Gantt chart for 12 months programme activities.

• Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.

• Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose and goal and objectively verifiable indicators, means of verification & assumptions.

• Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators,technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

• Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.

Teaching methods/activities

– Lecture – Assignment (Reading/Writing)

– Student's Book/Publication Review

– Student presentation

– Group Work

– Guest Lectures

Learning outcome

After successful completion of this course, the students are expected to be able to: Develop competencies in the areas of evaluation planning, indicator development, conducting evaluation and impact assessment and writing reports.

Suggested Reading

Adrienne M, Gundel S, Apenteng E and Pound B. 2011. Review of Literature on Evaluation Methods Relevant to Extension. Lindau, Switzerland: Global Forum for Rural Advisory Services, Lindau, Switzerland Bagnol B. 2014. Conducting participatory monitoring and evaluation. Pages 81-85 in FAO, Decision tools for family poultry development. FAO Animal Production and Health Guidelines, No. 1 6. Rome, Italy: FAO. Bennett CF. 1979. Analyzing impacts of extension programs. Washington, D.C., USA: U.S. Department of Agriculture. Boyle R and Le Maire D. 1999. Building effective evaluation capacity: lessons from practice. New Brunswick, NJ: Transaction Publishers. Bradford RW, Duncan, P.J. and Tarcy, B. 1999. Simplified Strategic Planning: A No-nonsense Guide for Busy People Who Want Results Fast. New York: Chandler House. Braverman MT and Engle M. 2009. Theory and rigor in Extension program evaluation planning. Journal of Extension 47(3). www.joe.org/joe/2009june/a1.php Chen H. 2012. Theory-driven evaluation: Conceptual framework, application and advancement. In: Strobl R., Lobermeier O., Heitmeyer W. (eds) Evaluation von Programmen und Projekten für einedemokratische Kultur. Springer VS, Wiesbaden Chen, H.T. 2011. Practical program evaluation: Theory-Driven Evaluation and the Integrated Evaluation Perspective. Thousand Oaks, CA: Sage. Dale R. 2004. Evaluating Development Programmes and Projects, New Delhi, India: Sage Publications. Duncan Haughey 2017. SWOT Analysis. https://www.projectsmart.co.uk/swot-analysis.php. Fetterman, D.M. 2012. Empowerment Evaluation: Learning to think like an evaluator. In M.C. Alkin (Ed.), Evaluation Roots (2nd edition) (pp. 304-322). GFRAS. 2012. Guide to evaluating rural extension. Lindau, Switzerland: Global Forum for Rural Advisory Services (GFRAS). Greene, J.C., Boyce, A., and Ahn, J. (2011). A values-engaged educative approach for evaluating education programs: A guidebook for practice. Champaign, IL: University of Illinois at Urbana-

• Isolation of fluorescent Pseudomonas;
• Preservation of bacterial cultures;
• Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences;
• Diagnosis and management of important diseases caused by bacteria and mollicutes.

Suggested Reading

Goto M. 1990. Fundamentals of Plant Bacteriology. Academic Press, New York. Jayaraman J and Verma JP. 2002. Fundamentals of Plant Bacteriology. Kalyani Publishers, Ludhiana. Mount MS and Lacy GH. 1982. Phytopathogenic Prokaryotes. Vols. I, II Academic Press, New York. Salle AJ. 1979. Fundamental Principles of Bacteriology 7th edn. Verma JP, Varma A and Kumar D. (Eds). 1995. Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.

Course Title : Plant Nematology
Course Code : PL PATH 504
Credit Hours : 2+1
Aim of the course

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

V. Theory

Unit I Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit II Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

Unit III Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit IV Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

Unit V Principles and practices of nematode management; integrated nematode management.

Unit VI Emerging nematode problems, Importance of nematodes in international trade and quarantine.

Practical

• Studies on kinds of nematodes- free-living, animal, insect and plant parasites;
• Nematode extraction from soil;
• Extraction of migratory endoparasites, staining for sedentary endoparasites;
• Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Reading

Dropkin VH. 1980. An Introduction to Plant Nematology. John Wiley & Sons, New York. Maggenti AR. 1981. General Nematology. Springer-Verlag, New York. Perry RN and Moens M. 2013. Plant Nematology. 2nd Ed. CABI Publishing: Wallingford, UK. Perry RN, Moens M, and Starr JL. 2009. Root-knot nematodes, CABI Publishing: Wallingford, UK. Sikora RA, Coyne D, Hallman J and Timper P. 2018. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture.3rd edn. CABI Publishing, England. Thorne G. 1961. Principles of Nematology. McGraw Hill, New Delhi. Walia RK and Bajaj HK. 2003. Text Book on Introductory Plant Nematology. ICAR, New Delhi. Walia RK and Khan MR. 2018. A Compendium of Nematode Diseases of Crop Plants, ICARAICRP (Nematodes), IARI, New Delhi.

Course Title : Principles of Plant Pathology
Course Code : PL PATH 505
Credit Hours : 2+1
Aim of the course

To introduce the subject of Plant Pathology, its concepts and principles.

V. Theory

Unit I Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit II Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit III Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Unit IV Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

Practical

SOIL SCIENCE

Course Title : Soil Physics
Course Code : Soil 501
Credit Hours : 2+1
Aim of the course
To impart basic knowledge about soil physical properties and processes in relation to plant growth.
Theory
Unit I Basic principles of physics applied to soils, soil as a three phase system.
Unit II Soil texture, textural classes, mechanical analysis, specific surface.
Unit III Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.Alleviation of soil physical constraints for crop production. Soil erosion and edibility
Unit IV Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.
Unit V Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.
Unit VI Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.
Unit VII Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.
Unit VIII
Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.
Unit IX
Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soiltemperature management.

Practical

• Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,

• Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Reading

• Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
• Ghildyal BP and Tripathi RP. 2001. Soil Physics. New Age International.
• Hanks JR and Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
• Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
• Hillel D. 1980. Applications of Soil Physics. Academic Press.
• Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.
• Hillel D. 1998. Environmental Soil Physics. Academic Press.
• Hillel D. 2003. Introduction to Environmental Soil Physics. Academic Press.
• Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
• Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley-Interscience.
• Kohnke H. 1968. Soil Physics. McGraw Hill.
• Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
• Oswal MC. 1994. Soil Physics. Oxford & IBH.

Course Title : Soil Fertility and Fertilizer Use
Course Code : Soil 502
Credit Hours : 3+1
Aim of the course
To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.
Theory
Unit I
Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.
Unit II Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.
Unit III Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid andalkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soilsand management under field conditions. Potassium - forms, equilibrium in soils and its agriculturalsignificance; mechanism of potassium fixation; management of potassium fertilizers under fieldconditions.
Unit V Sulphur - source, forms, fertilizers and their behavior in soils; roleincropsandhuman health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.
Unit VI Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.
Unit VII Common soil test methods for fertilizer recommendations; quantity–intensityrelationships; soil test crop response correlations and response functions.

Unit VIII Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; specialityfertilizersconcept, needand category.CurrentstatusofspecialityfertilizersuseinsoilsandcropsofIndia;

Unit IX Soil fertility evaluation - biological methods, soil, plant and tissue tests; soilquality in relation to sustainable agriculture, Determination of critical limit, DRIS Unit X Definition and concepts of soil health and soil quality; Longterm effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients(major and micro)
- Analysis of plants for essential elements(major and micro)

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Reading

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. Trace Elements in Soils and Plants. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Leigh J G. 2002. Nitrogen Fixation at the Millennium. Elsevier.
- Mengel K and Kirkby EA. 1982. Principles of Plant Nutrition. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. Micronutrients in Agriculture. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. Soils and Environmental Quality. 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. Soil Fertility and Fertilizers. 5th Ed. Prentice Hall of India.

• Troeh FR and Thompson LM. 2005. Soils and Soil Fertility. Blackwell.

Course Title : Soil Chemistry
Course Code : Soil 503
Credit Hours : 2+1
Suggested Reading

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory

Unit I Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

Unit III Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorptionisotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange–innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V Potassium, phosphate and ammonium fixation in soils covering specificand nonspecific sorption; precipitation-dissolution equilibria; Conceptof quantity/intensity(Q/ I)relationship; step and constant-rate K; managementaspects.

Unit VI Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

Unit VIII Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

VI. Practical

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter andconductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of chemical behaviour of soil and their utility in research for solving field problem.

Suggested Reading

• Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
• Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
• Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
• Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
• McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.

• Classification of soils using soil taxonomy
• Calculation of weathering indices and its application in soil formation
• Grouping soil susing available database in terms of soil quality

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil taxonomy and genesis and and their utility in research for solving field problem.

Suggested Reading

• Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu. Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. Soil Genesis • and Classification. 4th Ed. Panima Publ.
• Dixon JB and Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison.
• Grim RE. 1968. Clay Mineralogy. McGraw Hill.
• Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi. • Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi
• Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.
• USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
• Wade FA and Mattox RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH. • Wilding LP and Smeck NE. 1983. Pedogenesis and Soil Taxonomy: II. The Soil Orders. Elsevier.
• Wilding NE and Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy. I.

Course Title : Soil Erosion and Conservation
Course Code : Soil 505
Credit Hours : 2+1
Aim of the course

To enable students to understand various types of soil erosion and measures to betaken for controlling soil erosion to conserve soil and water.

Theory

Unit I History, distribution, identification and description of soil erosionproblems in India.

Unit II Forms of soil erosion; effects of soil erosion and factors affecting soilerosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affectingwater erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties andprecipitation.

Unit III Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit IV Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

Unit V Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

Unit VI Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring andevaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to a watersheds

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil conservation and their utility in research for solving field problem.

Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.) 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17.

• Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
• Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
• Hudson N. 1995. Soil Conservation. Iowa State University Press.
• Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi. • Oswal MC. 1994. Soil Physics. Oxford & IBH.

Course Title : Soil Biology and Biochemistry
Course Code : Soil 506
Credit Hours : 2+1
Aim of the course
To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.
Theory
Unit I Soilbiota, soil microbialecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soilbiota.
Unit II Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR.
Unit III Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and cropresidues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients. **Unit IV** Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.
Unit V Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.
Unit VI Biofertilizers–definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.
Unit VII Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms inpedogenesis – important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

• Determination of soil microbial population
• Soil microbial biomass carbon
• Elemental composition, fractionation of organic matter and functional groups
• Decomposition of organic matter in soil
• Soil enzymes
• Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation, S oxidation, P solubilization and mineralization of other micronutrients

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil microbes and their utility in research for solving field problem.

Suggested Reading

• Paul EA and Clark FE. Soil Microbiology and Biochemistry.
• Lynch JM. Soil Biotechnology
• Willey JM, Linda M. Sherwood and Woolverton CJ. Prescott's Microbiology.
• Subba Rao NS. Advances In Agricultural Microbiology.

Course Title : Soil Survey and Land Use Planning
Course Code : Soil 513
Credit Hours : 2+0
im of the course

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/ excessive rain-water in the catchment area for agricultural purposes in a watershed.

V. Theory

Unit I

Soil survey and its types; soil survey techniques- conventional and modern; soil series–characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for gene ration of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

Unit II

Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method sand soil-site suitability evaluation for different crops; land capability classification and constraints in application.

Unit IV

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

VI. Practical

• Aerial photo and satellite data interpretation for soil and land use

• Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in differentscales

• Land use planning exercises using conventional and RS tools

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit and exposure visit

VIII. Learning outcome

Planning for land use in proper way for higher crop productivity.

IX. Suggested Reading

• Boul SW, Hole ED, MacCraken RJ and Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.

• Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley & Sons.

Note : For minor courses please refer the concerned department's courses outline.

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Course Contents M.Sc. in Molecular Biology and Biotechnology

I. Course Title : Principles of Biotechnology

II. Course Code : MBB 501

III. Credit Hours : 3+0

IV. Aim of the course

• To understand the basics of Molecular biology, plant and microbial Biotechnology

• Importance and applications in agriculture, case studies and success stories

• Public education, perception, IPR and related issues

V. Theory

Unit I (12 Lectures) History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology etc. Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Unit II (16 Lectures) Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

Unit III (8 Lectures) Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications.Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications.

Unit IV (12 Lectures) Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions,Success stories in Biotechnology,

Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

VI. Suggested Reading

• Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York • Brown T A. 2010. Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell • Primrose SB and Twyman R. 2006. Principles of gene Manipulation 7th edition, Wiley Blackwell • Singh BD. 2012. Biotechnology: Expanding Horizons 4th edition, Kalyani publisher, New Delhi, India

Course Title : Fundamentals of Molecular Biology

Course Code : MBB 502

Credit Hours : 3+0

Aim of the course

• To understand the basics of DNA, RNA, structure, types and chromatin assembly.

• To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.

• To understand different levels of gene regulation and the pathways involved.

Theory

Unit I (8 Lectures) Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure andTypes of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Unit II (10 Lectures) Central dogma of Molecular Biology; DNA replication-Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in

Unit V (10 Lectures) Morphogenetic movements and the shaping of the body plan, Cell diversification, cellmemory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (C. elegans; Drosophila); Plant development.

Suggested Reading

• Alberts, B. 2017. Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.

• Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C., 2016. Molecular Cell Biology 8th Edition. W.H. Freeman & Co. New York.

• Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P., 2013 Essential of Cell Biology, WW Norton & Co, Inc.

• Cooper, G.M. and Hausman, R.E. 2013. The cell: A Molecular Approach 6th edition, Sinauer Associates, Inc.

Course Title : Techniques in Molecular Biology I

Course Code : MBB 504

Credit Hours : 0+3

Aim of the course

• To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology

• To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics

Practicals

• Good lab practices, preparation of buffers and reagents.

• Principle of centrifugation and spectrophotometry.

• Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.

• Isolation of plasmid DNA from bacteria.

• Growth of lambda phage and isolation of phage DNA.

• Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold).

• Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry

• PCR using isolated DNA. • PAGEGel electrophoresis.

• Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction. • Transformation of E. coli and selection of transformants

• Chromatographic techniques a. TLC b. Gel Filtration Chromatography, c. Ion exchange Chromatography, d. Affinity Chromatography • Dot blot analysis, Southern hybridization,Northern hybridization.

• Western blotting and ELISA.

• Radiation safety and non-radio isotopic procedure.

Suggested Reading

• Sambrook, J., and Russell, R.W. 2001. Molecular Cloning: A Laboratory Manual 3rd Edition, Cold spring harbor laboratory press, New York.

• Wilson, K., and Walker, J., 2018. Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.

• Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. Short Protocols in Molecular Biology 5th edition, Current Protocols publication.

Course Title : Omics and Systems Biology

Course Code : MBB 505

Credit Hours : 2+1

Aim of the course

• To get a basic overview of genomics, proteomics, ionomics and metabolomics

• To get a primary information on the application of omics science across the industry

Theory

Unit I (8 Lectures) Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, basics of ionomics analysis, different methods

Unit II (6 Lectures) Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest, etc., Study of protein interactions, Prokaryotic and yeast-based expression system and purification

Unit III (6 Lectures) Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

Unit IV (6 Lectures) Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively – MichaelisMenten Kinetics, Biological oscillators, Genetic oscillators,Quorum Sensing, Cellcell communication, Drosophila Development, Pathways to Network, Gene regulation at a single cell level, transcription network, Regulatory Circuits, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis

Practical (12)

• Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.

• BSA Standard curve preparation, Extraction of protein and estimation methods.

• Quantification of proteins from different plant tissues using spectrophotometry.

• 2-D Gel Electrophoresis, 2-D Image analysis.

• Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system). • Demonstration on MALDI-TOF.

• Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

Suggested Reading

• Primrose, S.B. and Twyman, R. 2006. Principles of Gene Manipulation 7th edition, Wiley Blackwell

• Wilson, K., and Walker, J. 2018. Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press

Course Title : Plant Tissue Culture

Course Code : MBB 509

Credit Hours : 2+1

Aim of the course

• To provide insight into principles of plant cell culture and genetic transformation.

• To get a hands on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

Theory

Unit I (12 Lectures) History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA

Unit II (12 Lectures) Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristemtip culture and micrografting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids - diploidization; Protoplast culture - isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization - Production of Somatic hybrids and Cybrids;, Wide hybridization - embryo culture and embryo rescuetechniques; Ovule, ovary culture and endosperm culture.

Unit III (12 Lectures) Large-scalecell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance; Artificial seeds, In vitro germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

Practical (12)

• Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.

• Micro-propagation of plants by nodal and shoot tip culture.

• Embryo culture to overcome incompatibility, Anther culture for haploid production.

• Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.

• Acclimatization of tissue culture plants and establishment in greenhouse.

• Virus indexing in tissue culture plants. (Using PCR and ELISA).

• Plan of a commercial tissue culture unit.

Suggested Reading

• Razdan, M.K. 2003. Introduction to plant tissue culture, 2nd edition, Oxford publications group

• Butenko, R.G. 2000. Plant Cell Culture University Press of Pacific

• Herman, E.B. 2008. Media and Techniques for Growth, Regeneration and Storage, Agritech Publications, New York, USA.

• Bhojwani, S.S and Dantu P. 2013. Plant Tissue Culture – An Introductory Text. Springer Publications.

• Gamborg, O.L and G.C. Philips (eds.). 2013. Plant Cell, Tissue and Organ culture-Lab Manual. Springer Science & Business media.

HORTICULTURE (FRUIT SCIENCE)
Course Contents M.Sc. (Hort.) in Fruit Science

I. Course Title : Tropical Fruit Production

II. Course Code : FSC 501

III. Credit Hours : (2+1)

Why this course ?

Tropical fruits occupy a distinct place in global fruit production. Apart from ecological specificities, tropical fruits enjoy favour among masses being delicious and nutritious. As such, the course has been designed to provide update knowledge on various production technologies of tropical fruits on sustainable basis.

Aim of the course

To impart comprehensive knowledge to the students on cultural and management practices for growing tropical fruits.

The course is organised as follows:

No.	Blocks	Units
1	Introduction	I Importance and Background
2	Agro-Techniques	I Propagation, Planting and Orchard Floor Management
3	Crop Management	I Flowering, Fruit-Set and Harvesting

Theory

Block 1: Introduction

Unit I:

Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Block 2: Agro-techniques

Unit I:

Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I:

Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

Crops

Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla, Ber, etc.

Practicals

• Distinguished features of tropical fruit species, cultivars and rootstocks (2);

• Demonstration of planting systems, training and pruning (3);

• Hands on practices on pollination and crop regulation (2);

• Leaf sampling and nutrient analysis (3);

• Physiological disorders-malady diagnosis (1);

• Physico-chemical analysis of fruit quality attributes (3);

• Field/ Exposure visits to tropical orchards (1);

• Project preparation for establishing commercial orchards (1).

Teaching Methods/ Activities

• Class room Lectures

• Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Learning outcome

The students are expected to equip themselves with know-how on agro-techniques for establishment and management of an orchard leading to optimum and quality fruit production of tropical fruits.

Suggested Reading

Bartholomew DP, Paull RE and Rohrbach KG. 2002. The Pineapple: Botany, Production, and Uses. CAB International. Bose TK, Mitra SK and Sanyal D. 2002. Fruits of India – Tropical and Sub-Tropical.3rd Edn. Naya Udyog, Kolkata. Dhillon WS. 2013. Fruit Production in India. Narendra Publ. House, New Delhi. Iyer CPA and Kurian RM. 2006. High Density Planting in Tropical Fruits: Principlesand Practices. IBDC Publishers, New Delhi. Litz RE. 2009. The Mango: Botany, Production and Uses. CAB International. Madhawa Rao VN. 2013. Banana. ICAR, New Delhi. Midmore D. 2015. Principles of Tropical Horticulture. CAB International. Mitra SK and Sanyal D. 2013. Guava, ICAR, New Delhi. Morton JF. 2013. Fruits of Warm Climates. Echo Point Book Media, USA. Nakasome HY and Paull RE. 1998. Tropical Fruits. CAB International. Paull RE and Duarte O. 2011. Tropical Fruits (Vol. 1). CAB International. Rani S, Sharma A and Wali VK. 2018. Guava (Psidium guajava L.). Astral, New Delhi. Robinson JC and Saúco VG. 2010. Bananas and Plantains. CAB International. Sandhu S and Gill BS. 2013. Physiological Disorders of Fruit Crops. NIPA, New Delhi. Schaffer B, Wolstenholme BN and Whiley AW. 2013. The Avocado: Botany, Production and Uses. CAB International. Sharma KK and Singh NP. 2011. Soil and Orchard Management. Daya Publishing House, New Delhi. Valavi SG, Peter KV and Thottappilly G. 2011. The Jackfruit. Stadium Press, USA.

Course Title : Subtropical and Temperate Fruit Production

Course Code : FSC 502

Credit Hours : (2+1)

Why this course ?

Agro-climatic diversity in India facilitates growing a wide range of fruits extending from tropical to subtropical to temperate fruits and nuts. To highlight their ecological specificities, seasonal variations and pertinent cultural practices, a course is designed exclusively for subtropical and temperate fruits. V. Aim of the course To impart comprehensive knowledge to the students on cultural and management practices for growing subtropical and temperate fruits.

The course is organised as follows:

No.	Blocks	Units
1	Introduction	Importance and Background
2	Agro-Techniques	Propagation, Planting and Orchard Floor Management
3	Crop Management	Flowering, Fruit-Set and Harvesting

Theory

Block 1: Introduction

Unit I:

Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Block 2: Agro-Techniques

Unit I:

Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I:

Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

Crops

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.

Practicals

• Distinguished features of fruit species, cultivars and rootstocks (2);

• Demonstration of planting systems, training and pruning (3);

• Hands on practices on pollination and crop regulation (2);

• Leaf sampling and nutrient analysis (3);

• Physiological disorders-malady diagnosis (1);

• Physico-chemical analysis of fruit quality attributes (3);

• Field/ Exposure visits to subtropical and temperate orchards (1);

• Project preparation for establishing commercial orchards (1).

Teaching Methods/ Activities

• Class room Lectures

• Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Learning outcome

After successful completion of the course, the student are expected to equip themselves with principles and practices of producing subtropical (citrus, grapes, litchi, pomegranate, etc.) and temperate fruits (apple, pear, peach, plum, apricot, cherries, berries, kiwifruit, etc.) and nuts (almond, walnut, pecan, etc.)

Suggested Reading

Chadha KL and Awasthi RP. 2005. The Apple. Malhotra Publishing House, New Delhi. Chadha TR. 2011. A Text Book of Temperate Fruits. ICAR, New Delhi Childers NF, Morris JR and Sibbett GS. 1995. Modern Fruit Science: Orchard and Small Fruit Culture. Horticultural Publications, USA. Creasy G and Creasy L. 2018. Grapes. CAB International. Davies FS and Albrigo LG. 1994. Citrus. CAB International. Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi. Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. Temperate and Subtropical Fruit Production. CAB International. Ladanyia M. 2010. Citrus Fruit: Biology, Technology and Evaluation. Academic Press. Layne DR and Bassi D. 2008. The Peach: Botany, Production and Uses. CABI. Menzel CM and Waite GK. 2005. Litchi and Longan: Botany, Production and Uses. CAB International. Pandey RM and Randey SN. 1996. The Grape in India. ICAR, New Delhi. Rajput CBS, and Haribabu RS. 2006. Citriculture, Kalyani Publishers, New Delhi. Sandhu S and Gill BS. 2013. Physiological Disorders of Fruit Crops. NIPA, New Delhi. Sharma RM, Pandey SN and Pandey V. 2015. The Pear – Production, Post-harvest Management and Protection. IBDC Publisher, New Delhi. Sharma RR and Krishna H. 2018. Textbook of Temperate Fruits. CBS Publishers and Distributors Pvt. Ltd., New Delhi. Singh S, Shivshankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. NIPA, New Delhi. Tromp J, Webster AS and Wertheim SJ. 2005. Fundamentals of Temperate Zone Tree Fruit Production.Backhuys Publishers, Lieden, The Netherlands. Webster A and Looney N. Cherries: Crop Physiology, Production and Uses. CABI. Westwood MN. 2009. Temperate Zone Pomology:Physiology and Culture. Timber Press, USA.

Course Title : Propagation and Nursery Management in Fruit Crops

Course Code : FSC 503

Credit Hours : (2+1)

Why this course ?

Availability of sufficient and healthy planting material is pivotal for expanding fruit culture. This necessitates requisite skill and efficient multiplication protocols for raising plants and their in house management prior to distribution or field transfer, hence the course is developed.

Aim of the course

To understand the principles and methods of propagation and nursery management in fruit crops.

The course is organised as follows:

No.	Blocks	Units
1	Introduction	I General Concepts and Phenomena
2	Propagation	I Conventional Asexual Propagation II Micropropagation
3	Nursery	I Management Practices and Regulation

Theory

Block 1: Introduction

Unit 1:

General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Block 2: Propagation

Unit I:

Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock and top working.

Unit II: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – in-vitro clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Block 3: Nursery

Unit I:

Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

Practical

• Hands on practices on rooting of dormant and summer cuttings (3);

• Anatomical studies in rooting of cutting and graft union (1);

• Hands on practices on various methods of budding and grafting (4);

• Propagation by layering and stooling (2);

• Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening (4);

• Visit to commercial tissue culture laboratories and accredited nurseries (2).

Teaching Methods/ Activities

• Class room Lectures

• Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Learning outcome

The student would be expected to equip to acquire skills and knowledge on principles and practices of macro and micropropagation and the handling of propagated material in nursery. X. Suggested Reading Bose TK, Mitra SK and Sadhu MK. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash, Kolkatta. Davies FT, Geneve RL and Wilson SB. 2018. Hartmann and Kester's Plant PropagationPrinciples and Practices. Pearson, USA/ PrenticeHall of India. New Delhi. Gill SS, Bal JS and Sandhu AS. 2016. Raising Fruit Nursery. Kalyani Publishers,New Delhi. Jain S and Ishil K. 2003. Micropropagation of Woody Trees and Fruits. Springer. Jain S and Hoggmann H. 2007. Protocols for Micropropagation of Woody Trees and Fruits. Springer. Joshi P. 2015. Nursery Management of Fruit Crops in India. NIPA, New Delhi. Love et al. 2017. Tropical Fruit Tree Propagation Guide. UH-CTAHR F_N_49. College of Tropical Agriculture and Human Resources University of Hawaii at Manwa, USA. Peter KV, eds. 2008. Basics of Horticulture. New India Publishing Agency, New Delhi. Rajan S and Baby LM. 2007. Propagation of Horticultural Crops. NIPA, New Delhi. Sharma RR. 2014. Propagation of Horticultural Crops. Kalyani Publishers, New Delhi. Sharma RR and Srivastav M. 2004. Propagation and Nursery Management. Intl. Book Publishing Co., Lucknow. Singh SP. 1989. Mist Propagation. Metropolitan Book Co. Singh RS. 2014. Propagation of Horticultural Plants: Arid and Semi-Arid Regions. NIPA, New Delhi. Tyagi S. 2019. Hi-Tech Horticulture. Vol I: Crop Improvement, Nursery and Rootstock Management. NIPA, New Delhi.

Course Title : Breeding of Fruit Crops

Course Code : FSC 504

Credit Hours : (2+1)

Why this course ?

Development of genetically improved varieties and rootstock is a continuous process which is realized through selection and breeding approaches. This is necessary to enhance the productivity and meet ever-changing climatic conditions and market/ consumer preferences. As such, a course is formulated to generate know-how on genetic and breeding aspects of fruit crops.

Aim of the course

To impart comprehensive knowledge on principles and practices of fruit breeding.

The course organisation is as under:

No.	Blocks	Units
1	Introduction	Importance, Taxonomy and Genetic Resources
2	Reproductive Biology	Blossom Biology and Breeding Systems
3	Breeding approaches	Conventional and Non-Conventional Breeding

Theory

Block 1: Introduction

Unit I:

Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status – species and cultivars, cytogenetics, genetic resources.

Block 2: Reproductive Biology

Unit I:

Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

Block 3: Breeding Approaches

Unit I:

Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts. Crops Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, Kiwifruit, Nuts

Practicals

- Exercises on bearing habit, floral biology (2);
- Pollen viability and fertility studies (1);
- Hands on practices in hybridization (3);
- Raising and handling of hybrid progenies (2);
- Induction of mutations and polyploidy (2);
- Evaluation of biometrical traits and quality traits (2);
- Screening for resistance against abiotic stresses (2);
- Developing breeding programme for specific traits (2);
- Visit to research stations working on fruit breeding (1).

Teaching Methods/ Activities

- Class room Lectures
- Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Learning outcome

After successful completion of the course, the students are expected to

• Have an understanding on importance and peculiarities of fruit breeding

• Have an updated knowledge on reproductive biology, genetics and inherent breeding systems.

• Have detailed knowledge of various methods/ approaches of breeding fruit crops

Suggested Reading

Abraham Z. 2017. Fruit Breeding. Agri-Horti Press, New Delhi. Badenes ML and Byrne DH. 2012. Fruit Breeding. Springer Science, New York. Dinesh MR. 2015. Fruit Breeding, New India Publishing Agency, New Delhi. Ghosh SN, Verma MK and Thakur A. 2018. Temperate Fruit Crop Breeding-Domestication to Cultivar Development. NIPA, New Delhi. Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer Science, New York. Jain SN and Priyadarshan PM. 2009. Breeding Plantation and Tree Crops: Tropical Species. Springer Science, New York. Jain S and Priyadarshan PM. 2009. Breeding Plantation and Tree Crops: Temperate Species. Springer Science, New York. Janick J and Moore JN. 1996. Fruit Breeding. Vols. I–III. John Wiley & Sons, USA. Kumar N. 2014. Breeding of Horticultural Crops:Principles and Practices. NIPA, N. Delhi. Moore JN and Janick J. 1983. Methods in Fruit Breeding. Purdue University Press, USA. Ray PK. 2002. Breeding Tropical and Subtropical Fruits. Narosa Publ. House, New Delhi.

Course Title : Canopy Management of Fruit Crops

Course Code : FSC 506

Credit Hours : (1+1)

Why this course ?

Plant architecture plays an important role in enhancing photosynthetic efficiency and resultant quantity and quality of the fruit produce. Manipulation of plant growth and development can be done by employing different training and pruning procedures besides through the use of growth regulators, specific rootstocks, etc. Hence this course is developed to address the aforesaid issues.

Aim of the course

To impart knowledge on principles and practices in management of canopy architecture for quality fruit production.

The course organisation is as follows:

No.	Blocks	Units
1	Canopy	Architecture Introduction, types and Classification
2	Canopy	Management Physical Manipulation and Growth regulation

Theory

Block 1: Canopy Architecture

Unit I:

Introduction, Types and Classification: Canopy management – importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area – Canopy classification.

Block 2: Canopy Management

Unit I:

Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

Practicals

• Study of different types of canopies (2);

• Training of plants for different canopy types (2);

• Canopy development through pruning (2);

• Understanding bearing behaviour and canopy management in different fruits (2);

• Use of plant growth regulators (2);

• Geometry of planting (1);

• Development of effective canopy with support system (2);

• Study on effect of different canopy types on production and quality of fruits (2).

Teaching Methods/ Activities

• Class room Lectures

• Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Learning outcome

After successful completion of the course, the students are expected to learn • The basic principles of canopy management to modify plant architecture • The skills on training and pruning of fruit crops, and growth regulation X. Suggested Reading Bakshi JC, Uppal DK and Khajuria HN. 1988. The Pruning of Fruit Trees and Vines. Kalyani Publishers, New Delhi. Chadha KL and Shikhamany SD. 1999. The Grape, Improvement, Production and Post Harvest Management. Malhotra Publishing House, Delhi. Iyer CPA and Kurian RM.

2006. High Density Planting in Tropical Fruits: Principles and Practices. IBDC Publishers, New Delhi. Pradeepkumar T. 2008. Management of Horticultural Crops. NIPA, New Delhi. Singh G. 2010. Practical Manual on Canopy Management in Fruit Crops. Dept. of Agriculture and Co-operation, Ministry of Agriculture (GoI), New Delhi. Srivastava KK. 2012. Canopy Management in Fruits. ICAR, New Delhi

Course Title : Growth and Development of Fruit Crops

Course Code : FSC 507

Credit Hours : (2+1)

Why this course ?

The underlying principles and parameters of growth and development needs to be understood for harnessing maximum benefits in term of yield and quality. External environment and inherent hormonal and metabolic pathways considerably determine growth dynamics. Thus, a course is formulated to develop know-how on physiological and physical aspects of growth and development processes.

Aim of the course

To develop comprehensive understanding on growth and development of fruit crops.

The course is structured as under:-

No.	Blocks	Units
1	Introduction	General Concepts and Principles
2	Environment and Development	Climatic Factors, Hormones and Developmental Physiology
3	Stress Management	Strategies for Overcoming Stress

Theory

Block 1: Introduction

CAB International. Epstein E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. John Wiley & Sons, NY, USA. Faust M. 1989. Physiology of Temperate Zone Fruit Trees. John Willey & Sons, NY, USA. Fosket DE. 1994. Plant Growth and Development: a Molecular Approach. Academic Press, USA. Leopold AC and Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, New Delhi. Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Salisbury FB and Ross CW. (Eds.) Plant Physiology. 4th Ed.Wadsworth Publications, USA. Schafeer, B. and Anderson, P. 1994. Handbook of Environmental Physiology of Fruit Crops. Vol. 1 & 2. CRC Press. USA. Seymour GB, Taylor JE and Tucker GA. 1993. Biochemistry of Fruit Ripening. Chapman & Hall, London.

Course Title : Minor Fruit Production

Course Code : FSC 513

Credit Hours : (2+1)

Why this course ?

Apart from commercially grown fruits, several other fruits inspite of being rich in nutrients and potential future crops, remains neglected/ underexploited. The hardy nature coupled with the possibility of diversification (newly domesticated crops) further adds to their importance. The course outlines the efforts made in standardizing agro-techniques for propagation and cultivation besides know-how on their nutraceutical value and other uses.

Aim of the course

To import basic knowledge underexploited minor fruit crops.

The course is structured as under:-

No.	Blocks	Units
1	Introduction	Occurrence, Adoption and General Account
2	Agro-Techniques	Propagation and Cultural Practices
3	Marketing and utilization	Post-Harvest Management

Learning outcome

On successful completion of the course, the students are expected to know about

• Various minor fruits hitherto neglected and their commercial value

• Efforts made to domesticate minor fruits and standardization of agro-techniques.

• Their utilization in processing industry.

Theory

Block 1: Introduction

Unit I:

Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

Unit I:

Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

Unit I:

Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioxidant values; their uses for edible purpose and in processing industry Crops Bael, chironji, fig, passion fruit, jamun, phalsa, karonda, woodapple, cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and other minor fruits of regional importance

Practicals

• Visits to institutes located in the hot and cold arid regions of the country (2);
• Identification of minor fruits plants/ cultivars (2);

• Collection of leaves and preparation of herbarium (1);

• Allelopathic studies (2);

• Generating know-how on reproductive biology of minor fruits (4);

• Fruit quality attributes and biochemical analysis (3);

• Project formulation for establishing commercial orchards in fragile ecosystems (1).

Teaching Methods/ Activities

• Class room Lectures

• Laboratory/ Field Practicals

• Student Seminars/ Presentations

• Field Tours/ Demonstrations

• Assignments

Suggested Reading

Ghosh SN, Singh A and Thakur A. 2017. Underutilized Fruit Crops: Importance and Cultivation. Jaya Publication House, New Delhi. Krishna H and Sharma RR, 2017. Fruit Production: Minor Fruits. Daya Publishing House, New Delhi. Mazumdar BC. 2014. Minor Fruit Crops of India: Tropical and Subtropical. Daya Publication House, New Delhi. Nath V, Kumar D, Pandey V and Pandey D. 2008. Fruits for the Future. Satish Serial Publishing House, New Delhi. Pareek OP, Sharma S, and Arora RK. 2007. Underutilised Edible Fruits and Nuts, IPGRI, Rome. Peter KV. 2010. Underutilized and Underexploited Horticultural Crops. NIPA, New Delhi. Rana JC and Verma VD. 2011. Genetic Resources of Temperate Minor Fruit (Indigenous and Exotic). NBPGR, New Delhi. Saroj PL and Awasthi OP. 2005. Advances in

HORTICULTURE (VEGETABLE SCIENCE)

Course Contents M.Sc. (Hort.) in Vegetable Science

Course Title : Production of Cool Season Vegetable Crops

Course Code : VSC 501

Credit Hours : (2+1)

Why this course ?

Cool season vegetables are a major source of dietary fibres, minerals and vitamins. Some of these vegetables also contribute protein, fat and carbohydrate. Most of the leafy and root vegetables are rich in minerals, especially in micro-elements such as copper, manganese and zinc. Vegetables differ in their temperature requirement for proper growth and development. Most of the winter vegetable crops are cultivated in cool season when the monthly mean temperature does not exceed 21°C. Even in temperate climate, these vegetables are cultivated in spring summer in hilly tracks where the daytime temperature in summer is less than 21°C. The students of vegetable science need to have an understanding of production technology of important cool season vegetable crops and their management.

Aim of the course

To impart knowledge and skills on advancement in production technology of cool season vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Production of cool season vegetable crops	I Bulb and tuber crops
		II Cole crops
		III Root crops
		IV Peas and beans
		V Leafy vegetables

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods,hrydroponics and aeroponics, precision farming, cropping

system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I

Bulb and tuber crops—Onion, garlic and potato.

Unit II

Cole crops—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.

Unit III

Root crops—Carrot, radish, turnip and beetroot.

Unit IV

Peas and beans—Garden peas and broad bean.

Unit V

Leafy vegetables—Beet leaf, fenugreek, coriander and lettuce.

Practical

• Scientific raising of nursery and seed treatment;
• Sowing and transplanting;
• Description of commercial varieties and hybrids;
• Demonstration on methods of irrigation, fertilizers and micronutrients application; • Mulching practices, weed management;
• Use of plant growth substances in cool season vegetable crops;
• Study of nutritional and physiological disorders;
• Studies on hydroponics, aeroponics and other soilless culture; • Identification of important pest and diseases and their control;
• Preparation of cropping scheme for commercial farms;
• Visit to commercial farm, greenhouse/ polyhouses;
• Visit to vegetable market;
• Analysis of benefit to cost ratio.

Teaching Methods/ Activities

• Classroom lectures
• Assignment (written and speaking)
• Student presentation • Hands on training of different procedures
• Group discussion

Learning outcome

After successful completion of this course, the students are expected to:

• Appreciate the scope and scenario of cool season vegetable crops in India
• Acquire knowledge about the production technology and post-harvest handling of cool season vegetable crops
• Calculate the economics of vegetable production in India

Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. Naya udyog. Bose TK, Som MG and Kabir J. (Eds.). 1993. Vegetable crops. Naya prokash. Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house. Chadha KL. (Ed.). 2002. Hand book of horticulture. ICAR. Chauhan DVS. (Ed.). 1986. Vegetable production in India. Ram prasad and sons. Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani publishers. Gopalakrishanan TR. 2007. Vegetable crops. New India publ. agency. Hazra P and Banerjee MK and Chattopadhyay A. 2012. Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana, 199 p. Hazra P. 2016. Vegetable Science. 2nd edn, Kalyani publishers, Ludhiana. Hazra P. 2019. Vegetable production and technology. New India publishing agency, New Delhi. Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. Modern technology for vegetable production, New India publishing agency, New Delhi, 413p Rana MK. 2008. Olericulture in India. Kalyani publishers, New Delhi. Rana MK. 2008. Scientific cultivation of vegetables. Kalyani publishers, New Delhi. Rana MK. 2014. Technology for vegetable production. Kalyani publishers, New Delhi. Rubatzky VE and Yamaguchi M. (Eds.). 1997. World vegetables: principles, production and nutritive values. Chapman and Hall. Saini GS. 2001. A text book of oleri and flori culture. Aman publishing house. Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker. Shanmugavelu KG. 1989. Production technology of vegetable crops. Oxford and IBH. Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co. Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. comm. res. centre. Thamburaj S and Singh N. (Eds.), 2004. Vegetables, tuber crops and spices. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Course Title : Production of Warm Season Vegetable Crops

Course Code : VSC 502

Credit Hours : (2+1)

Why this course ?

Unlike cool-season vegetables, warm-season vegetable crops require higher soil and air temperature, thus, they are always planted after the last frost date ranging from late spring after the last frost date to late summer. Daytime temperature may still be warm enough but drop so much at night-time that the weather is not suitable for warm-season crops any longer. In general summer vegetables require a little higher temperature than winter vegetables for optimum growth. In summer vegetables, the edible portion is mostly botanical fruit. The students of vegetable science need to have an understanding of production technology of important warm season vegetable crops and thereafter their management.

Aim of the course

To impart knowledge and skills on advancement in production technology of warm season vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Production of warm season vegetable	1. Fruit vegetables crops 2. Beans 3. Cucurbits 4. Tuber crops 5. Leafy vegetables

Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/ planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

Unit I

Fruit vegetables—Tomato, brinjal, hot pepper, sweet pepper and okra.

Unit II
Beans—French bean, Indian bean (Sem), cluster bean and cowpea.
Unit III
Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.
Unit IV
Tuber crops—Sweet potato, elephant foot yam, tapioca, taro and yam.
Unit V
Leafy vegetables—Amaranth and drumstick.
Practical
• Scientific raising of nursery and seed treatment;
• Sowing, transplanting, vegetable grafting;
• Description of commercial varieties and hybrids;
• Demonstration on methods of irrigation, fertilizers and micronutrients application;
• Mulching practices, weed management;
• Use of plant growth substances in warm season vegetable crops;
• Study of nutritional and physiological disorders;
• Studies on hydroponics, aeroponics and other soilless culture;
• Identification of important pest and diseases and their control;
• Preparation of cropping scheme for commercial farms;
• Visit to commercial farm, greenhouse/ polyhouses;
• Visit to vegetable market;
• Analysis of benefit to cost ratio.

Teaching Methods/ Activities
• Classroom Lectures
• Assignment (written and speaking)
• Student presentation • Hands on training of different procedures
• Group discussion

Learning outcome
After successful completion of this course, the students are expected to:
• Appreciate the scope and scenario of warm season vegetable crops in India
• Acquire knowledge about the production technology and post-harvest handling of warm season vegetable crops
• Calculate the economics of vegetable production in India
Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. Naya udyog. Bose TK, Som MG and Kabir J. (Eds.). 1993. Vegetable crops. Naya prokash. Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house. Chadha KL. (Ed.). 2002. Hand book of horticulture. ICAR. Chauhan DVS. (Ed.). 1986. Vegetable production in India. Ram prasad and sons. Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani. Gopalakrishanan TR. 2007. Vegetable crops. New India publ. agency. Hazra P and Banerjee MK and Chattopadhyay A. 2012. Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana, 199 p. Hazra P. 2016. Vegetable science. 2ndedn, Kalyani publishers, Ludhiana. Hazra P. 2019. Vegetable production and technology. New India publishing agency, New Delhi. Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. Modern technology for vegetable production, New India publishing agency, New Delhi, 413p Rana MK. 2008. Olericulture in India. Kalyani Publishers, New Delhi. Rana MK. 2008. Scientific cultivation of vegetables. Kalyani Publishers, New Delhi. Rubatzky VE and Yamaguchi M. (Eds.). 1997. World vegetables: principles, production and nutritive values. Chapman and Hall. Saini GS. 2001. A text book of oleri and flori culture. Aman publishing house. Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker. Shanmugavelu KG., 1989. Production technology of vegetable crops. Oxford and IBH. Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co. Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. comm. res. centre. Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Course Title : Growth and Development of Vegetable Crops

Course Code : VSC 503

Credit Hours : (2+1)

Why this course ?

In agriculture, the term plant growth and development is often substituted with crop growth and yield since agriculture is mainly concerned with crops and their economic products. Growth, which is irreversible quantitative increase in size, mass, and/ or volume of a plant or its parts, occurs with an expenditure of

metabolic energy. Plant development is an overall term, which refers to various changes that occur during its life cycle. In vegetable crops, development is a series of processes from the initiation of growth to death of a plant or its parts. Growth and development are sometimes used interchangeably in conversation, but in a botanical sense, they describe separate events in the organization of the mature plant body. The students of vegetable science need to have an understanding of growth and development of vegetable crops.

Aim of the course

To teach the physiology of growth and development of vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Growth and development of vegetable crops	1.Introduction and phytohormones 2.Physiology of dormancy and germination 3. Abiotic factors 4. Fruit physiology 5. Morphogenesis and tissue culture

Theory

Unit I

Introduction and phytohormones—Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/ biosynthesis and mode of action; Growth analysis and its importance in vegetable production.

Unit II

Physiology of dormancy and germination—Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.

Unit III

Abiotic factors—Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance.

Unit IV

Fruit physiology—Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism,

ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.

Unit V

Morphogenesis and tissue culture—Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops.

Practical

• Preparation of plant growth regulator's solutions and their application;
• Experiments in breaking and induction of dormancy by chemicals;
• Induction of parthenocarpy and fruit ripening;
• Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables;
• Growth analysis techniques in vegetable crops;
• Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

Teaching Methods/ Activities

• Classroom Lectures
• Assignment (written and speaking)
• Student presentation
• Hands on training of different procedure
• Group discussion

Learning outcome

After successful completion of this course, the students are expected to:
• Acquire knowledge about the growth and development of plants in vegetable crops • Distinguish between primary and secondary growth in plant stems
• Understand how hormones affect the growth and development of vegetable crops

Suggested Reading

Bleasdale JKA. 1984. Plant physiology in relation to horticulture (2nd Edition) MacMillan. Gupta US. Eds. 1978. Crop physiology. Oxford and IBH, New Delhi. Kalloo G. 2017. Vegetable grafting: Principles and practices. CAB International Krishnamoorti HN. 1981. Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi. Leopold AC and Kriedemann PE. 1981. Plant growth and development, Tata McGraw-Hill, New Delhi. Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p. Peter KV. (Eds). 2008. Basics of horticulture. New India publication agency, New Delhi. Rana MK. 2011. Physio-biochemistry and

Biotechnology of Vegetables. New India Publishing Agency, Pritam Pura, New Delhi. Saini et al. (Eds.). 2001. Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur. Wien HC. (Eds.). 1997. The physiology of vegetable crops. CAB International.

Course Title : Principles of Vegetable Breeding

Course Code : VSC 504

Credit Hours : (2+1)

Why this course ?

Plant breeding has been practiced for thousands of years, since beginning of human civilization. Vegetable breeding, which is an art and science of changing the traits of plants in order to produce desired traits, has been used to improve the quality of nutrition in products for human beings. A breeding programme, which is needed if current varieties are not producing up to the capacity of the environment, can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics, make use of knowledge of genetics and chromosomes to more complex molecular techniques. When different genotypes exhibit differential responses to different sets of environmental conditions, a genotype x environment (GxE) interaction is said to occur. Breeding high yielding open pollinated varieties and hybrids, and exploitation of location specific component of genotypic performance are the only options left to reduce this increasing gap between the production and requirements in view of decreasing land resources. Noevertheless, vegetable breeding is an integral part of plant breeding but this will be re-modeled to suit to breeding of different vegetables crops. The students of vegetable science who are having breeding as major subject need to have an understanding of vegetable breeding principles.

Aim of the course

To teach basic principles and practices of vegetable breeding

The course is constructed given as under:

No.	Block	Unit
1.	Principles of vegetable breeding	I. Importance and history II. Selection procedures III. Heterosis breeding IV. Mutation breeding V. Polyploid breeding VI. Ideotype breeding

Theory

Unit I

Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II

Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III

Heterosis breeding- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms.

Unit IV

Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

Unit V

Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In-vitro and molecular techniques in vegetable improvement.

Practical

• Floral biology and pollination behaviour of different vegetables;
• Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.;
• Breeding system and handling of filial generations of different vegetables;
• Exposure to biotechnological lab practices;
• Visit to breeding farms.

Teaching Methods/ Activities

• Classroom Lectures
• Assignment (written and speaking)
• Student presentation
• Hands on training of different procedures
• Group discussion

Learning outcome

After successful completion of this course, the students are expected to:
• Acquire knowledge about the principles of vegetable breeding

• Improve yield, quality, abiotic and biotic resistance, other important traits of vegetable crops
• Understand how the basic principles are important to start breeding of vegetable crops

Suggested Reading

Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA. Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA. Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA. Peter KVand Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488. Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA. Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi. Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Title : Protected Cultivation of Vegetable CropS

Course Code : VSC 507

Credit Hours : (2+1)

Why this course ?

India is the second largest producer of vegetable crops in the world. However, its vegetable production is much less than the requirement, if a balanced diet is provided to every individual. There are different ways and means to achieve this target. Protected cultivation, which is the modification of the natural environment to achieve optimum plant growth. Is the most intensive form of crop production with a yield per unit area up to ten times superior to that of a field crop. During winter under north-east Indian conditions, it is difficult to grow tomato, capsicum, cucurbits, french bean, amaranth, etc. in open field. However, various types of protected structure have been developed for growing some high value crops by providing protection from the excessive cold. Production of off-season vegetable nurseries under protected structure has become a profitable business. The main purpose of raising nursery plants in protected structure is to get higher profit and disease free seedlings in off-season to raise early crop in protected and open field condition. The low cost polyhouse is economical for small and marginal farmers, who cannot afford huge cost of high-tech polyhouse. Besides supplying the local markets, the production of polyhouse vegetables is greatly valued for its export potential

and plays an important role in the foreign trade balance of several national economies. The students of vegetable science need to have an understanding of protected cultivation of vegetable crops.

Aim of the course

To impart latest knowledge about growing of vegetable crops under protected environmental conditions

The course is constructed given as under:

No.	Block	Unit
1.	Protected cultivation of vegetable	I. Scope and importance crops II. Types of protected structure III. Abiotic factors IV. Nursery raising V. Cultivation of crops VI. Solutions to problems

Theory

Unit I

Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/ greenhouse structures.

Unit II

Types of protected structure- Classification and types of protected structuresgreenhouse/ polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system.

Unit III

Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

Unit IV

Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.

Unit V

Cultivation of crops- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures.

Unit VI

Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

Practical

• Study of various types of protected structure;
• Study of different methods to control temperature, carbon dioxide and light;
• Study of different types of growing media, training and pruning systems in greenhouse crops;
• Study of fertigation and nutrient management under protected structures;
• Study of insect pests and diseases in greenhouse and its control;
• Use of protected structures in hybrid seed production of vegetables;
• Economics of protected cultivation (Any one crop); • Visit to established green/ polyhouses/ shade net houses in the region.

VIII. Teaching Methods/ Activities

• Classroom Lectures
• Assignment (written and speaking)
• Student presentation
• Hands on training of different procedures
• Group discussion

Learning outcome

After successful completion of this course, the students are expected to:

• Appreciate the scope and scenario of protected cultivation of vegetable crops in India
• Acquire knowledge about the effect of abiotic factors on growth, flowering and production of vegetable crops
• Gaining knowledge about the designing of various low cost protected structures
• Adopting the raising of vegetable seedlings in low cost protected structures as entrepreneur

Suggested Reading

Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture. Malhotra Pub. House. Chandra S and Som V. 2000. Cultivating vegetables in green house. Indian horticulture 45:17- 18. Kalloo G and Singh K. (Eds.). 2000. Emerging scenario in vegetable research and development.Research periodicals and Book publ. house. Parvatha RP. 2016. Sustainable crop protection under protected cultivation. E-Book Springer. Prasad S and Kumar U. 2005. Greenhouse management for horticultural crops. 2nd Ed.Agrobios. Resh HM. 2012. Hydroponic food production. 7thEdn. CRC Press. Singh B. 2005. Protected cultivation of vegetable crops. Kalyani publishers, New Delhi Singh DK and Peter KV. 2014. Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi. Singh S, Singh B and Sabir N. 2014. Advances in protected cultivation. New India publishing agency, New Delhi. Tiwari GN. 2003. Green house technology for controlled environment. Narosa publ. house.

Course Title : Production of Underutilized Vegetable Crops

Course Code : VSC 509

Credit Hours : (2+1)

Why this course ?

With increasing population and fast depletion of natural resources, it has become essential to explore the possibilities of using newer indigenous plant resources. Underutilized crops are plant species that are used traditionally by the country people for their food, fibre, fodder, oil, or medicinal properties but have yet to be adopted by large scale agriculturalists. In general, underutilized plants constitute those plant species that occur as life support species in extreme environmental conditions and threatened habitats, having genetic tolerance to survive under harsh conditions and possess qualities of nutritional and/ or industrial importance for a variety of purposes. Underutilized crops are those plant species with under-exploited potential for contributing to food security, health (nutritional or medicinal), income generation and environmental services. Once the underutilized food crops are properly utilized, they may help to contribute in food security, nutrition, health, income generation and environmental services. The underutilized crops can be defined as the crops, which being region specific are less available, less utilized or rarely used. These underutilized crop species have also been described as rare, minor, orphan, promising and little-used vegetable crops. The students of

vegetable science need to have an understanding of production technology of underutilized vegetable crops.

Aim of the course

To impart knowledge about production technology of lesser utilized vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Production of underutilized vegetable crops	I. Stem and bulb crops II. Cole and salad crops III. Gourds and melons IV. Leafy vegetables V. Yams and beans

Theory

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/ hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post harvest management of:

Unit I

Stem and bulb crops—Asparagus, leek and chinese chive

Unit II

Cole and salad crops—Red cabbage, chinese cabbage, kale, sweet corn and baby corn

Unit III

Leafy vegetables—Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

Unit IV

Gourds and melons—Sweet gourd, spine gourd, teasle gourd, round gourd, and little/ Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin

Unit V

Yam and beans—Elephant foot yam, yam, yam bean, lima bean and winged bean

Practical

• Identification and botanical description of plants and varieties;

• Seed/ planting material;

• Production, lay out and method of planting;

• Important cultural operations;

• Identification of important pests and diseases and their control;

• Maturity standards and harvesting;

• Visit to local farms.

Teaching Methods/ Activities

• Delivering of lectures by power point presentation

• Assignment (written and speaking)

• Student presentation

• Hands on training of different procedures

• Group discussion Learning outcome After successful completion of this course, the students are expected to:

• Appreciate the scope and scenario of production of underutilized vegetable crops in India • Acquire knowledge about the production technology of underutilized vegetable crops • Adopting production of lesser utilised crops as entrepreneur

Suggested Reading

Bhat KL. 2001. Minor vegetables-untapped potential. Kalyani publishers, New Delhi. Indira P and Peter KV. 1984. Unexploited tropical vegetables. Kerala agricultural university, Kerala. Pandey AK. 2011. Aquatic vegetables. Agrotech publisher academy, New Delhi. Peter KV. (Eds.). 2007-08. Underutilized and underexploited horticultural crops. Vol.1-4, New India publishing agency, Lucknow. Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p. Rana MK. 2018. Vegetable crop science. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1-1380-3521-8 Rubatzky VE and Yamaguchi M. 1997. World vegetables: vegetable crops. NBPGR, New Delhi.

Course Title : Postharvest Management of Vegetable Crops

Course Code : VSC 514

Credit Hours : (2+1)

Why this course ?

Vegetables are highly perishable crops as they have great quantity and quality loss after harvest. Hence, they require integrated approach to arrest their spoilage, which causes tonnes of vegetable produce annually. Lack of postharvest awareness and inadequacy of equipments are the major problems in postharvest chain, which lead to a serious post-harvest loss in the developing countries every year. A comprehensive understanding of postharvest factors causing deterioration is necessary to overcome these challenges. Pre and postharvest management such as use of improved varieties, good cultural practices, good pre and postharvest handling practices, management of temperature, relative humidity and storage atmosphere according to crop requirement, use of permitted chemicals, design of

appropriate packaging material and storage structures are some of the control measures used in reducing postharvest losses, therefore, this course was customized.

Aim of the course

To facilitate deeper understanding of principles and to acquaint the student with proper handling and management technologies of vegetable crops for minimizing the post-harvest losses

The course is organized as follows:

No.	Blocks	Units
1.	Post-harvest management of	I Importance and scope vegetable crops
		II Maturity indices and biochemistry
		III Harvesting and losses factors
		IV Packinghouse operations
		V Methods of storage

Theory

Unit I

Importance and scope—Importance and scope of post-harvest management of vegetables

Unit II

Maturity indices and biochemistry—Maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods

Unit III

Harvesting and losses factors—Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses

Unit IV

Packing house operations—Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

Unit V

Methods of storage—Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber, storage disorders like chilling injury in vegetables

Practical

• Studies on stages and maturing indices;

• Ripening of commercially important vegetable crops;

• Studies of harvesting, pre-cooling, pre-treatments, physiological disorders-chilling injury; • Improved packaging;

• Use of chemicals for ripening and enhancing shelf life of vegetables;

• Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release; • Storage of important vegetables;

• Cold chain management;

• Visit to commercial packinghouse, cold storage and control atmosphere storage.

Teaching Methods/ Activities

• Classroom lectures including ppt.

• Students group discussion

• Individual or group assignments (writing and speaking)

• Presentation of practical handwork

Learning outcome

After successful completion of this course, the students are expected to be able to understand:

• Regulation of postharvest losses by using chemicals and growth regulators

• Pre and postharvest treatments for extending shelf life of vegetable crops

• Packinghouse operations for extending the shelf life of vegetable crops

• Successful storage of vegetable crops

Suggested Reading

Chadha KL and Pareek OP. 1996. Advances in horticulture. Vol. IV. Malhotra Publ. House. Chattopadhyay SK. 2007. Handling, transportation and storage of fruit and vegetables. GeneTech books, New Delhi. Haid NF and Salunkhe SK. 1997. Postharvest physiology and handling of fruits and vegetables. Grenada

HORTICULTURE (PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS)

I. Course Title : Production of Plantation Crops
II. Course Code : PSM 501
III. Credit Hours : (2+1)
IV. Why this course ?

Plantation crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course willimpart theoretical as well as hands-on experience to the learner on scientificproduction technology of various plantation crops in Indian perspectives. It willprovide comprehensive knowledge in this regard.

V. Aim of the course

The course is designed to provide both basic and applied knowledge on various aspects of production technology of plantation crops grown in India.

The course is organized as follows:

No	Blocks	Units
1	Importance of Plantation Crops	I Role of plantation crops
		II Export potential
		III Promotional programmes
2	Production Technology	I Varietal wealth
		II Propagation and nursery management
		III Agro techniques
3	Harvest and Post-harvest management	I Maturity indices and harvest
		II Post harvest management

VI. Theory

Block 1: Importance of Plantation Crops

Unit 1: Role of plantation crops: Role of plantation crops in national economy, area-production statistics at national and international level,classification, clean development mechanism and carbon sequestrationpotential of plantation crops.

Unit 2: Export potential: Export potential, problems and prospects and IPR issues in plantation crops.

Unit 3: Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation crops.

Block 2: Production Technology

Unit 1: Varietal wealth: Botany, taxonomy, species, cultivars and improved varieties in plantation crops.
Unit 2: Propagation and nursery management: Plant multiplication including *in-vitro*multiplication, nursery techniques and nursery management in plantation crops.
Unit 3: Agro techniques: Systems of cultivation, cropping systems, multitiercropping, climate and soil requirements, systems of planting, high densityplanting, nutritional requirements, water requirements, fertigation,moisture conservation, role of growth regulators, macro and micronutrients, nutrient deficiency symptoms, physiological disorders, shaderegulation, weed management, training and pruning, crop regulation,plant protection, management of drought, precision farming.
Block 3: Harvest and Post harvest management
Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods,harvesting seasons and mechanized harvesting in plantation crops.
Unit 2: Post harvest management: Post harvest handling including primaryprocessing, grading, packaging, storage and benefit cost analysis of plantation crops.
Crops
Coconut, Arecanut, Oilpalm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine
VII. Practical
• Description of botanical and varietal features;
• Selection of mother palms and seedlings;
• Nursery techniques;
• Soil and water conservation measures;
• Nutrient deficiency symptoms;
• Manuring practices;
• Pruning and training methods;
• Maturity standards;
• Harvesting;
• Project preparation for establishing plantations;
• GAP in plantation crops;
• Exposure visits to commercial plantations, research institutes.
VIII. Teaching Methods/ Activities
• Lecture
• Assignment (Reading/ Writing)

• Demonstration
• Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to:
• Develop the technical skill in commercial cultivation of plantation crops
• Be able to start plantation crop-based enterprises

X. Suggested Reading

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press.
Anonymous. 1985. *Rubber and its Cultivation*. The Rubber Board of India.
Chopra VL and Peter KV. 2005. *Handbook of Industrial Crops*. Panima.
Choudappa P, Anitha K, Rajesh MK and Ramesh SV. 2017. *Biotechnology of Plantation Crops*.
Daya Publishing House, New Delhi
Choudappa P, Niral V, Jerard BA and Samsudeen K. 2017. *Coconut*. Daya Publishing House,
New Delhi.
*e-manual*on Advances in Cashew Production Technology. ICAR –Directorate of Cashew
Research, Puttur –574 202, DK, Karnataka.
Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.
Joshi P. 2018. *Text Book on fruit and plantation crops*. Narendra Publishing House, New Delhi
Kurian A and Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.
Nair MK, Bhaskara Rao EVV, Nambia KKN and Nambiar MC. 1979. *Cashew*. CPCRI,
Kasaragod.
Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).
Asia Pacific Business Press Inc.
Peter KV. 2002. *Plantation Crops.* National Book Trust.
Pillay PNR. 1980. *Handbook of natural rbber production in India*. Rubber Research Institute,
Kottayam. pp.668.

Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2007. *Management of*
Horticultural Crops. Parts I, II. New India Publ. Agency.
Ramachandra *et al.* 2018. *Breeding of Spices and Plantation crops*. Narendra Publishing House,
New Delhi.
Ranganathan V. 1979. *Hand Book of Tea Cultivation.* UPASI, Tea Res. Stn. Cinchona.
Sera T, Soccol CR, Pandey A, Roussos S *Coffee Biotechnology and Quality*. Springer, Dordrecht.
Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology*
(Developments in Crop Science). Elsevier Science.
Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and*
Future directions. SPRINGER; ISBN: 978-81-322-2261-3.
Sharangi AB and Acharya SK. 2008. *Quality management of Horticultural crops*. Agrotech
Publishing House, Udaipur; ISBN: 81-8321-090-2.
Srivastava HC, Vatsaya and Menon, KKG. 1986. *Plantation Crops – Opportunities and*
Constraints. Oxford and IBH.
Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford and IBH.

I. Course Title : Production of Spice Crops
II. Course Code : PSM 502
III. Credit Hours : (2+1)
IV. Why this course ?

Spice crops play an important role in the national economy of India. These cropsalso provide livelihood security to a large section of farmers. This course willimpart theoretical as well as hands-on experience to the learner on scientificproduction technology of various spice crops in Indian perspectives. It will providecomprehensive knowledge in this regard.

V. Aim of the course

The course is designed to provide both basic and applied knowledge on variousaspects of production technology of spice crops grown in India.The course is organized as follows:

No	Blocks	Units
1	Importance of Spice Crops	I Role of spice crops
		II Classification of spice crops
2	Production Technology	I Varietal wealth
		II Propagation and nursery management
		III Agro techniques
3	Harvest and Post harvest management	I Maturity indices and harvest
		II Post harvest management

VI. Theory

Block 1: Importance of spice crops

Unit 1: Role of Spice crops: Introduction, importance of spice crops,pharmaceutical significance, historical accent, present status – nationaland international, future prospects, role of Spices board and otherdevelopment agencies.

Unit 2: Classification of spice crops: Major spices, minor spices, seed spices,tree spices, herbal spices.

Block 2: Production Technology

Unit 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids in spice crops.

Unit 2: Propagation and nursery management: Seed, vegetative and micro propagation methods, nursery techniques and nursery management practices.

Unit 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/ planting times and methods, seed rate and seed treatment,nutritional and irrigation requirements, intercropping, mixed cropping,intercultural operations, weed control, mulching, plant protection,precision farming, physiological disorders, protected cultivation.

Block 3: Harvest and Post harvest management

Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods,harvesting seasons, mechanized harvesting.

Unit 2: Post harvest management: Post harvest management including primaryprocessing, grading, packaging and storage, GMP in major spice crops.

Crops

Black pepper, small and large Cardamom, Turmeric, Ginger, Garlic, Coriander,

Fenugreek, Cumin, Fennel, Ajwain, Saffron, Vanilla, Nutmeg, Clove, Cinnamon,Allspice, Tamarind, Garcinia

VII. Practical

• Identification of seeds and plants;
• Botanical description of plant;
• Varietal features;
• Planting material production;
• Field layout and method of planting;
• Cultural practices;
• Harvest maturity, harvesting;
• Drying, storage, packaging;
• Primary processing;
• GAP in spice crops;
• GMP in spice crops;
• Short term experiments on spice crops;
• Exposure visits to spice farms, research institutes.

VIII. Teaching Methods/ Activities

• Lecture
• Assignment (Reading/ Writing)
• Demonstration
• Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to:
• Develop the technical skill in commercial cultivation of spice crops
• Be able to start spice-based enterprises

X. Suggested Reading

Agarwal S, Sastry EVD and Sharma RK. 2001. *Seed Spices: Production, Quality, Export.* Pointer
Publ.
Arya PS. 2003. *Spice Crops of India.* Kalyani.
Bose TK, Mitra SK, Farooqi SK and Sadhu MK. Eds. 1999. *Tropical Horticulture.* Vol.I. Naya
Prokash.
Chadha KL and Rethinam P. Eds. 1993. *Advances in Horticulture.* Vols. IX-X. *Plantation Crops*
and Spices. Malhotra Publ. House.

Sharangi AB. 2018. Indian Spices "*The legacy, production and processing of India's treasured*
export." Springer International publishing AG, Part of Springer Nature 2018, Cham,
Switzerland.
Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and*
Future directions. SPRINGER; ISBN: 978-81-322-2261-3.
Sharangi AB and Acharya SK. 2008. *Quality Management of Horticultural crops*. Agrotech
Publishing House, Udaipur; ISBN: 81-8321-090-2.
Thamburaj S and Singh N. Eds. 2004. *Vegetables, Tuber Crops and Spices*, ICAR.
Tiwari RS and Agarwal A. 2004. *Production Technology of Spices*. International Book Distr.Co.

I. Course Title : Production of Medicinal and Aromatic Crops
II. Course Code : PSM 503
III. Credit Hours : (2+1)
IV. Why this course ?
Medicinal and aromatic crops play an important role in the national economy ofIndia. These crops also provide health security to all. This course will impart theoretical as well as hands-on experience to the learner on scientific productiontechnology of various medicinal and aromatic crops in Indian perspectives. It willprovide comprehensive knowledge in this regard.
V. Aim of the course
To impart comprehensive knowledge on the production technology of importantmedicinal and aromatic crops
The course is organized as follows:
No Blocks Units
1 Importance of Medicinal and I Classification of medicinal
Aromatic Crops and aromatic crops
II Medicinal plant based industry
III Aromatic plant based industry
2 Production technology I Varietal wealth
II Propagation and nursery management
III Agro techniques

3 Harvest and Post harvest I Maturity indices and harvest
management II Post harvest management

Theory

Block 1: Importance of Medicinal and Aromatic Crops

Unit 1: Classification of medicinal and aromatic crops: Importance of medicinal plants, Importance of aromatic plants, Role in national economy, utility sectors of medicinal and aromatic crops, classification of medicinal and aromatic crops, role of institutions, Medicinal Plant Board and NGO's in research and development of medicinal and aromatic crops.

Unit 2: Medicinal and plant-based industry: Indian system of medicine, traditional systems of medicine, tribal medicine, medicinal industry, source of medicinal plants, area, production, export and import of major crops, problems, prospects and challenges, IPR issues.

Unit 3: Aromatic plant based industry: Essential oils, classification, physical and chemical properties and storage of essential oils. Indian perfumery industry, area, production, export and import status of major aromaticcrops, history and advancements, problems, prospects and challenges, IPR issues.

Block 2: Production technology of medicinal and aromatic crops

Unit 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids in medicinal and aromatic crops.

Unit 2: Propagation and nursery management: Seed, vegetative and micro propagation methods, nursery techniques and nursery management practices.

Unit 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/ planting times and methods, seed rate and seed treatment,nutritional and irrigation requirements, intercropping, mixed cropping,intercultural operations, weed control, mulching, plant protection.

Block 3: Harvest and Post harvest management

Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in medicinal and aromatic crops.

Unit 2: Post harvest management: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in medicinal and aromatic crops.

Crops

A. Medicinal crops: Senna, periwinkle, medicinal coleus, aswagandha, glory lily,sarpagandha, *Dioscorea* sp., *Aloe vera*, *Andrographis paniculata*, *Digitalis*, medicinalsolanum, isabgol, opium poppy, safedmusli, *Stevia rebaudiana, Mucuna pruriens,Piper longum, Plumbago zeylanica*

B. Aromatic crops: Palmarosa, lemongrass, citronella, vetiver, mentha, patchouli,sweet flag, jasmine, geranium, artemisia, lavender, *Ocimum* sp., eucalyptus, sandal

VI. Practical

• Description of botanical and varietal features;
• Nursery techniques;
• Lay out and planting;
• Manuring practices;
• Maturity standards;
• Harvesting;
• Primary processing;
• Extraction of oils;
• Herbarium preparation;
• Project preparation for establishing herbal gardens;
• GAP in medicinal and aromatic crops;
• GMP in medicinal and aromatic crops;
• Exposure visits to institutes, herbal gardens and industries.

VII. Teaching Methods/ Activities

• Lecture
• Assignment (Reading/ Writing)
• Demonstration
• Exposure visits

VIII. Learning outcome

After successful completion of this course, the students are expected to:

• Develop the technical skill in commercial cultivation of medicinal and aromaticcrops
• Be able to start medicinal and aromatic crop-based enterprises

IX. Suggested Reading

Atal CK and Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR,
Jammu.
Barche S. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*.
New India Publishing Agency, New Delhi.
Das K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi

Farooqi AA and Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*.
Orient Longman Publ.
Farooqi AA, Khan MM and Vasundhara M. 2001. *Production Technology of Medicinal and*
Aromatic Crops. Natural Remedies Pvt. Ltd.
Gupta RK. 2010. *Medicinal and Aromatic plants*. CBS publications.
Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books. Jain SK. 2000. *Medicinal Plants.*
National Book Trust.
Khan IA and Khanum A. 2001. *Role of Biotechnology in Medicinal and Aromatic Plants*. Vol.
IX. Vikaaz Publ.
Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India
Publ. Agency.
Panda H. 2002. *Medicinal Plants Cultivation and their Uses.* Asia Pacific Business Press.
Panda H. 2005. *Aromatic Plants Cultivation, Processing and Uses.* Asia Pacific Business Press.
Ponnuswami *et al.* 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New
Delhi.
Prajapati SS, Paero H, Sharma AK and Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro
Bios.
Ramawat KG and Merillon JM. 2003. *BioTechnology – Secondary Metabolites*. Oxford and IBH.
Shankar SJ. 2018. *Comprehensive post harvest technology of flowers, medicinal and aromatic*
plants. Narendra Publishing House, New Delhi.
Skaria PB, Samuel M, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aromatic Plants*.
New India Publ. Agency.

I. Course Title : Breeding of Plantation and Spice Crops
II. Course Code : PSM 504

III. Credit Hours : (2+1)

IV. Why this course ?

Plantation and spice crops play an important role in the national economy of India.For maximizing the production, productivity and quality of plantation and spicecrops, fundamental knowledge on breeding methods of the major crops is essential.This course will impart theoretical as well as hands-on experience to the learneron reproductive biology, breeding methods and breeding achievements in variousplantation and spice crops

V. Aim of the course

To impart comprehensive knowledge on the principles and practices in the breedingof important plantation and spice crops

The course is organized as follows:

No	Blocks	Units
1	Genetic diversity	I Species and cultivar diversity
		II Germplasm evaluation
2	Crop improvement	I Breeding objectives
		II Breeding methods
3	Breeding achievements and future thrusts	I Breeding achievements
		II Future thrusts

VI. Theory

Block 1: Genetic diversity

Unit I: Species and cultivar diversity: Floral and reproductive biology,cytogenetics, male sterility, incompatibility, wild and cultivated species,popular cultivars.

Unit II: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm.

Block 2: Crop improvement

Unit I: Breeding objectives: Breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.

Unit II: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding,improvement of quality traits, resistance breeding for biotic and abioticstresses.

Block 3: Breeding achievements and future thrusts

Unit I: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features.

Unit II: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience

Crops

A. Plantation crops: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee,Tea, Palmyrah, Betel vine

B. Spice crops: Black pepper, small and large cardamom, Ginger, Turmeric, Fenugreek, Coriander, Fennel, Cumin, Ajwain, Garlic, Nutmeg, Cinnamon, Clove,Allspice, Garcinia, Tamarind

VII. Practical

• Characterization and evaluation of germplasm;
• Floral biology, anthesis; pollen behaviour, fruit set;
• Practices in hybridization, selfing and crossing techniques;
• Polyploidy breeding;
• Mutation breeding;
• Induction of somaclonal variation and screening the variants;
• Evaluation of biometrical traits and quality traits;
• Salient features of improved varieties and cultivars;
• Screening for biotic and abiotic stresses;
• Bioinformatics;
• Exposure visits to research institutes for plantation and spice crops.

VIII. Teaching Methods/ Activities

• Lecture
• Assignment (Reading/Writing)
• Demonstration
• Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to:
• Develop the technical skill in breeding of plantation and spice crops
• Be able to start plantation and spice crop-based seed production/ nursery centres

X. Suggested Reading

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press.

Anonymous. 1985. *Rubber and its Cultivation.* The Rubber Board of India.

Chadha KL, Ravindran PN and Sahijram L. 2000. *Biotechnology in Horticultural and Plantation*
Crops. Malhotra Publ. House.

Chadha KL. 1998. *Advances in Horticulture*. Vol. IX,X. *Plantation and Spices Crops.* Malhotra

New Delhi.
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House,New Delhi
Ravindran PN. 2002. *Cardamom, the genus Elettaria*. CRC press
Ravindran PN. 2003. *Cinnamon and cassia.* CRC press
Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press
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Ravindran PN. 2017. *The Encyclopedia of Herbs and Spices*. CABI
Sera T, Soccol CR, Pandey A, Roussos S. *Coffee Biotechnology and Quality.* Springer, Dordrecht.
Sethuraj MR and Mathew NT. 1992.*Natural Rubber: Biology, Cultivation and Technology*
(Developments in Crop Science). Elsevier Science.
Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and*
Future directions. SPRINGER; ISBN: 978-81-322-2261-3.
Thampan PK. 1981. *Hand Book of Coconut Palm.* Oxford and IBH.

I. Course Title : Breeding of Medicinal and Aromatic Crops
II. Course Code : PSM 505
III. Credit Hours : (1+1)
IV. Why this course ?

Medicinal and aromatic crops play an important role in the national economy ofIndia. For maximizing the production, productivity and quality of medicinal andaromatic crops, fundamental knowledge on breeding methods of the major crops isessential. This course will impart theoretical as well as hands-on experience to thelearner on reproductive biology, breeding methods and breeding achievements invarious medicinal and aromatic crops.

V. Aim of the course

To impart comprehensive knowledge on the principles and practices in the breedingof important medicinal and aromatic crops.

The course is organized as follows:

No	Blocks	Units
1	Genetic diversity	1. Species and cultivar diversity
		2. Germplasm evaluation
2 C	rop improvement	1. Breeding objectives
		2. Breeding methods
3 Breeding achievements and future thrusts		1. Breeding achievements
		2. Future thrusts

VI. Theory

Block 1: Genetic diversity

Unit 1: Species and cultivar diversity: Floral and reproductive biology,cytogenetics, male sterility, incompatibility, wild and cultivated species,popular cultivars.

Unit 2: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues.

Block 2: Crop improvement

Unit 1: Breeding objectives: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.

Unit 2: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding,improvement of quality traits, resistance breeding for biotic and abiotic stresses.

Block 3: Breeding achievements and future thrusts

Unit 1: Breeding achievements: Breeding achievements in terms of releasedvarieties, parentage, salient features.

Unit 2: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climateresilience.

Crops

A. Medicinal crops: *Cassia angustifolia, Catharanthus roseus, Gloriosa superba,Coleus forskohlii, Stevia rebaudiana, Withania somnifera, Papaver somniferum,Plantago ovata, Chlorophytum* sp., *Rauvolfia serpentina, Aloe vera, Piper longum,Plumbago zeylanica*

B. Aromatic crops: Mint, geranium, patchouli, lemon grass, palmarosa, citronella,vetiver, Artemisia, ocimum, lavender, *Kaempferia galanga*, eucalyptus

VII. Practical

• Description of botanical features;
• Cataloguing of cultivars, varieties and species in medicinal and aromatic crops;
• Floral biology;
• Selfing and crossing;
• Evaluation of hybrid progenies;
• Induction of economic mutants;
• High alkaloid and high essential oil mutants;
• Evolution of mutants through physical and chemical mutagens;
• Introduction of polyploidy;
• Screening of plants for biotic and abiotic stress;
• *In-vitro* breeding in medicinal and aromatic crops.

VIII. Teaching Methods/ Activities

• Lecture
• Assignment (Reading/ Writing)
• Demonstration
• Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to:
• Develop the technical skill in breeding of medicinal and aromatic crops
• Be able to start medicinal and aromatic crop-based seed production/ nursery centres

X. Suggested Reading

Chadha KL and Gupta, R. 1995. *Advances in Horticulture.* Vol. XI. Malhotra Publ. House.
Farooqi AA, Khan MM and Vasundhara M. 2001. *Production Technology of Medicinal and*
Aromatic Crops. Natural Remedies Pvt. Ltd.
Gupta R.K. 2010. *Medicinal and Aromatic plants*. CBS publications
Jain SK. 2000. *Medicinal Plants*. National Book Trust.
Julia F and Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas
Publ.
Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India
Publ. Agency.

Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House,
New Delhi
Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi
Ponnuswami *et al.* 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New
Delhi
Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing
Agency, New Delhi

I. Course Title : Systematics of Plantation and Spice Crops
II. Course Code : PSM 506
III. Credit Hours : (1+1)
IV. Why this course ?
Plantation and spice crops play an important role in the national economy of India.For the crop improvement programme of these crops, fundamental knowledge onorigin and development, evolutionary process, taxonomy and cytogenetics and ismost essential. This course will impart theoretical knowledge to the learner on theorigin and distribution, evolutionary process, taxonomy and cytogenetics of variousplantation and spice crops.
V. Aim of the course
To impart basic knowledge on the origin and development, evolutionary process,taxonomy, chemotaxonomy, cytogenetics and genetic resources of plantation andspice crops.
The course is organized as follows:
No Blocks Units
1 Origin and evolution 1. Centre of origin
2. Systematics
2 Genetic diversity 1. Species and cultivar diversity
2. Germplasm
3 Cataloguing 1. Descriptors
2. DUS guidelines
VI. Theory
Block 1: Origin and evolution
Unit I: Centre of origin: Centre of origin, distribution, taxonomical status,

phylogeny.
Unit II: Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics.
Block 2: Diversity
Unit I: Species and cultivar diversity: Wild and related species, cultivars.
Unit II: Germplasm: Indigenous and exotic germplasm.
Block 3: Cataloguing
Unit I: Descriptors: Biovarsity/ NBPGR descriptors and their salient features.
Unit II: DUS guidelines: DUS guidelines, molecular aspects of systematics.
Crops
A. Plantation crops: Coconut, Arecanut, Oil Palm, Tea, Coffee, Cocoa, Cashew,
Rubber, Betel Vine
B. Spice crops: Black Pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon,
Clove, Vanilla, Coriander, Fennel, Cumin, Fenugreek, Garlic
VII. Practical
• Genus, species and cultivar features of various plantation and spice crops;
• Characterization based on descriptors;
• Characterization based on DUS guidelines;
• Study of sex forms and floral biology;
• Study of molecular markers;
• Exposure visits to national institutes including NBPGR.
VIII. Teaching Methods/ Activities
• Lecture
• Assignment (Reading/ Writing)
• Demonstration
• Exposure visits
IX. Learning outcome
After successful completion of this course, the students are expected to:
• have thorough understanding on the systematics of plantation and spice crops
X. Suggested Reading
Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press
Chadha KL and Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.
Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications,

Diwan AP and Dhakad NK. 1996. *Genetics and Development*. Anmol Publications Private
Limited, New Delhi.
E-manual on Advances in Cashew Production Technology. ICAR –Directorate of Cashew
Research, Puttur –574 202, DK, Karnataka
Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).
Asia Pacific Business Press Inc.
Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute,
Kottayam. pp.668
Ponnuswami *et al.* 2018. Blossom biology of Horticultural crops. Narendra Publishing House,
New Delhi
Ponnuswami *et al.* 2018. Botany of Horticultural crops. Narendra Publishing House, New Delhi
Ravindran PN. 2000. *Black pepper, Piper nigrum*. CRC press
Ravindran PN. 2002. *Cardamom, the genusElettaria*. CRC press
Ravindran PN. 2003. *Cinnamon and cassia.* CRC press
Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press
Ravindran PN. 2007. *Turmeric, the genus curcuma*. CRC press
Ravindran PN. 2017. *The Encyclopedia of Herbs and Spices*. CABI
Sera T, Soccol CR, Pandey A and Roussos S. *Coffee Biotechnology and Quality*. Springer,
Dordrecht.
Sethuraj MR and Mathew NT. 1992.*Natural Rubber: Biology, Cultivation and Technology*
(*Developments in Crop Science*). Elsevier Science.
Sharma G. 2009. *Systematics of fruit Crops*. New India Publishing House, India.
Strickberger MW. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India
Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publishers

I. Course Title : Growth and Development of Plantation, Spice,

Medicinal and Aromatic Crops
II. Course Code : PSM 509
III. Credit Hours : (2+1)
IV. Why this course ?

Understanding on growth and development of plantation, spice, medicinal and aromatic crops is vital towards quality production as well as yield. Fundamentalknowledge on developmental physiology, biology and biochemistry and the associatedchanges is most essential. This course will impart theoretical as well as hands-onexperience to the learner on these aspects of PSMA crops for improving theirproductivity.

V. Aim of the course

To impart comprehensive knowledge on the growth, developmental stages and cropregulation to increase the productivity in PSMAs

The course is organized as follows:

No	Blocks	Units
1	Growth and development	I Stages of growth
		II Growth pattern
		III Assimilate partitioning
2	Canopy management	I Canopy management
		II Plant bio regulators
3	Developmental physiology and biochemistry	I Vegetative phase
		II Flowering and fruit set
		III Growth and development during stress

VI. Theory

Block 1: Growth, development, assimilate partitioning and plant bio regulators

Unit I: Stages of growth: Growth and development, definitions, components,photosynthetic productivity, different stages of growth, growth curves,growth analysis, morphogenesis in PSMAs.

Unit II: Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effectof light, temperature, photoperiod.

Unit III: Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition.

Block 2: Canopy management

Unit I: Canopy management: Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs.

Unit II: Plant bio regulators: plant bio regulators- auxins, gibberellins,cytokinins, ethylene, inhibitors and retardants, basic functions,biosynthesis and role in crop growth and development.

Block 3: Developmental physiology and biochemistry

Unit I: Vegetative phase: Developmental physiology and biochemistry during dormancy, bud break, juvenility.

Unit II: Flowering and fruit set

Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.

Unit III: Growth and development process during stress: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

VII. Practical

- Dormancy mechanisms in seeds, seed rhizomes;
- Techniques of growth analysis;
- Evaluation of photosynthetic efficiency under different environments;
- Technologies for crop regulation in cashew, coffee, cocoa, etc.;
- Root shoot studies, flower thinning, fruit thinning;
- Crop regulation for year round production;
- Use of growth regulators in PSMA crops.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Demonstrations
- Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to

- have thorough understanding on growth and development of PSMA crops
- will enable them to formulate crop regulation strategies for productivity enhancement.

X. Suggested Reading

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press

Buchanan BW. Gruiessam and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*.

John Wiley and Sons.
*E- manual*on Advances in Cashew Production Technology. ICAR -Directorate of Cashew
Research, Puttur –574 202, DK, Karnataka
Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*.Wiley.
Fosket DE. 1994. *Plant Growth and Development: A Molecular approach*. Academic Press.
Leoplod AC and Kriedermann PE. 1985. *Plant Growth and Development.* 3rdEd.McGraw-Hill
Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).
Asia Pacific Business Press Inc.
Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute,
Kottayam. pp.668
Ravindran PN. 2000. *Black pepper, Piper nigrum*. CRC press
Ravindran PN. 2002. *Cardamom, the genus Elettaria*. CRC press
Ravindran PN. 2003. *Cinnamon and cassia.* CRC press
Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press
Ravindran PN. 2007. *Turmeric, the genus curcuma*. CRC press
Ravindran PN. 2017. *The Encyclopedia of Herbs and Spices*. CABI
Roberts JS Downs and P Parker. 2002. *Plant Growth Development*. In: *Plants* (L. Ridge, Ed.),
pp. 221-274, Oxford University Press
Salisbur FB and Ross CW. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
Sera T, Soccol CR, Pandey A. and Roussos S. *Coffee Biotechnology and Quality*. Springer,
Dordrecht.
Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology*
(Developments in Crop Science). Elsevier Science.

HORTICULTURE (PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS)

PSMA 501 Production of Plantation Crops 2+1

Objective

To impart basic knowledge about the importance and production technology of plantation crops grown in India.

Theory

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

Crops

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Wattle and betel vine

Practical

Description of botanical and varietal features, selection of mother palms and seedlings in coconut and arecanut, soil test crop response studies and manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, Visit to plantations.

Suggested Readings

Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.

Chopra VL & Peter KV. 2005. *Handbook of Industrial Crops*. Panima.

Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.

Kurian A & Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.

Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.

Peter KV. 2002. *Plantation Crops*. National Book Trust.

Pradeep Kumar T, Suma B, Jyothibhaskar&Satheesan KN. 2008.*Management of Horticultural Crops*. Part I, II. New India Publ. Agency.

Rai PS &Vidyachandram B. 1981. *Review of Work Done on Cashew*. UAS, Research Series No.6, Bangalore.

Ranganathan V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.

Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford & IBH.

Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

PSMA 502 Production Technology of Spice Crops 2+1

Objective

To impart basic knowledge about the importance and productiontechnology of spices grown in India.

Theory

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection

measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of:

UNIT I

Black pepper, cardamom

UNIT II

Clove, cinnamon and nutmeg, allspice

UNIT III

Turmeric, ginger and garlic

UNIT IV

Coriander, fenugreek, cumin, fennel, ajowain, dill, celery

UNIT V

Tamarind, garcinia and vanilla

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice crops.

Suggested Readings

Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.

Arya PS. 2003. *Spice Crops of India*. Kalyani.

Bhattacharjee SK. 2000. *Hand Book of Aromatic Plants*. Pointer Publ.

Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. *Tropical Horticulture*. Vol.I. NayaProkash.

Chadha KL &Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*. Malhotra Publ. House.

Gupta S. (Ed.). *Hand Book of Spices and Packaging with Formulae*. Engineers India Research Institute, New Delhi.

Kumar NA, Khader P, Rangaswami&Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH.

Nybe EV, Miniraj N & Peter KV. 2007. *Spices*. New India Publ. Agency.

Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.

Peter KV. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. WoodheadPubl. Co. UK and CRC USA

Pruthi JS. (Ed.). 1998. *Spices and Condiments*. National Book Trust

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management andPost Harvest Technology*. ICAR.

Purseglove JW, Brown EG, Green CL & Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Tiwari RS & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.

Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

PSMA 503 Production Technology for Medicinal and Aromatic Crops 2+1

Objective

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

Theory

UNIT I

Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production.

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea*sp., *Aloe vera*, *Phyllanthus amarus,Andrographis paniculata.*

UNIT III

Production technology for Medicinal solanum, Isabgol, Poppy, Safed musli, *Stevia rebaudiana, Mucuna pruriens, Ocimum sp.*

UNIT IV

Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI

Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT VII

Production technology for palmarosa, lemongrass, citronella, **v**ettiver, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, oreganum.

UNIT VIII

Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional

plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations.

UNIT IX

Institutional support and international promotion of essential oil and perfumery products.

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units – Visit to CIMAP.

Suggested Readings

Atal CK &Kapur BM. 1982. *Cultivation and Utilization of Aromatic Plants*. RRL, CSIR, Jammu.

Atal CK &Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Farooqi AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.

Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.

Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Khan IA & Khanum A. *Role of Bio Technology in Medicinal and Aromatic Plants*. Vol. IX. Vkaaz Publ.

Kurian A & Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Panda H. 2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.

Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios.

Ramawat KG &Merillon JM. 2003. *BioTechnology-Secondary Metabolites*. Oxford & IBH.

Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aomatic Plants*. New India Publ. Agency.

PSMA 504 Breeding of Plantation Crops and Spices 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts.

Crops

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Black pepper and cardamom

UNIT VI: Ginger and turmeric

UNIT VII: Fenugreek, coriander, fennel, celery and ajwoain

UNIT VIII: Nutmeg, cinnamon, clove and allspice

Practical

Characterization and evaluation of germplasm accessions, Blossom biology, studies on pollen behaviour, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for biotic and abiotic stresses, haploid culture, protoplast culture and fusion- induction of somaclonal variation and screening the variants. Identification and familiarization of spices; floral biology anthesis; fruit set; selfing and crossing techniques; description of varieties. Salient features of improved varieties and cultivars from public and private sector, bioinformatics, visit to radiotracer laboratory, national institutes for plantation crops and plant genetic resource centers, genetic transformation in plantation crops for resistance to biotic stress/quality improvement etc.

Suggested Readings

Anonymous 1985. *Rubber and its Cultivation*. The Rubber Board of India.

Chadha KL &Rethinam P. (Eds.).1993. *Advances in Horticulture*. Vol. IX. *Plantation Crops and Spices*. Part-I. Malhotra Publ. House.

Chadha KL, Ravindran PN &Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops.* Malhotra Publ. House.

Chadha KL. 1998. *Advances in Horticulture*. Vol. IX. *Plantation and Spices Crops*. Malhotra Publishing House, New Delhi.

Chopra VL & Peter KV. *Handbook of Industrial Crops*. Haworth Press. Panama International Publishers, New Delhi (Indian Ed.).

Damodaran VK, Vilaschandran T &Valsalakumari PK. 1979. *Research on Cashew in India*. KAU, Trichur.

Ferwerden FP & Wit F. (Ed.). 1969. *Outlines of Perennial Crop Breeding in the Tropics*. H. Veenman&Zonen.

Harver AE. 1962. *Modern Coffee Production*. Leonard Hoff.

Raj PS &Vidyachandra B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.

Thampan PK 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

PSMA 505 Breeding of Medicinal and Aromatic Crops 2+1

Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint.

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

Suggested Readings

Atal CK &Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Chadha KL & Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.

Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Julia F & Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas Publ.

Kurian A & Asha Sankar, M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Prajapati ND, Paero Hit SS, Sharma AK, Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios (India).

Skaria P Babu. 2007. *Aromatic Plants*. New India Publ. Agency.

Thakur RS, Pauri HS & Hussain A. 1989. *Major Medicinal Plants of India* CSIR.

PSMA 506 Processing of Plantation Crops, Spices Medicinal and Aromatic Crops 2+1

Objective

To facilitate deeper understanding on principles and practices of post harvest technology of plantation crops, spices, medicinal and aromatic crops.

Theory

UNIT I

Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika,vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils.

UNIT II

Processing of produce from plantation crops, *viz*. coconut, arecanut, cashewnut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber etc.

UNIT III

Processing of medicinal plants– dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safedmusli, senna, aloe, catharanthus, etc. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on active principles.

UNIT IV

Extraction and analysis of active principles using TLC / HPLC / GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Study of aroma compounds and value addition. Nano-processing technology in medicinal and aromatic plants.

Practical

Study of processing of different spices and plantation crops. Study of processing of medicinal plants, their drying and storage. Extraction of active ingredients from different spices and herbs using TLC, HPLC, GC/CG-MS technology. Distillation, solvent extraction from aromatic plants – davana, mint, rosemary, citronella, lavender, jasmine, etc.

Identification of different odoriferous factors in essential oil with GLC/GCMS. Physico-chemical and sensory evaluation of oils and oleoresin. Value added products from spices and plantation crops.

Suggested Readings

Chadha KL et al. (Eds.). 1993-95. *Advances in Horticulture*. Vol. IX.*Plantation Crops and Spices*. Malhotra Publishing House, New Delhi.

Fellows PJ. 1988. *Food Processing Technology*. Ellis Horwood International. Switzerland.

Fennema OR. 1985. *Food Chemistry*. Marcel Dekker.

Kumar N, Abdul Khader ML, Rangaswamy P &Ikrulappan I. 1994. *Spices, Plantation Crops, Medicinal and Aromatic Plants*. Rajalakshmi Publ.

Mandal RC. 1996. *Coconut Production and Processing Technology*. Agro. Bot.

Mandal RC. 1997. *Cashew: Production and Processing Technology*. Agro. Bot.

Masada Y.1986. *Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry*. John Wiley & Sons.

Paine FA. 1987. *Modern Processing, Packaging and Distributions Systems for Food*. AVI Publ.

Peter KV. (Ed.). 2001. *Handbook of Herbs and Spices*. Vols.I-III. Wood Head Publishing Co., UK & CRC, USA.

Sudheer KP & Indira V. 2008. *Post-Harvest Technology of Horticultural Crops*. Horticulture Science Series. New India Publ. Agency.

Thampan PK. 1981. *Handbook of Coconut Palm*. Oxford & IBH.

PSMA 507 Organic Spice and Plantation Crop Production Technology 2+1

Objective

To educate principles, concepts and production of organic farming in spice and plantation crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of spice and plantation crops.

UNIT II

Organic production of spice crops and plantation crops, *viz.* pepper, cardamom, turmeric, ginger, cumin, vanilla, coconut, coffea, cocoa, tea, arecanut.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc.; Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, water management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

HORTICULTURE (FLORICULTURE AND LANDSCAPE ARCHITECTURE)

FLA 501 Breeding of Flower Crops and Ornamental Plants (2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of flower crops and ornamental plants.

Theory

UNIT I

Principles -- Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India.

UNIT II

Genetic inheritance -- of flower colour, doubleness, flower size, fragrance, post harvest life.

UNIT III

Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.

UNIT IV

Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia,gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium.

UNIT V

Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia,

cosmos,dianthus, snap dragon, pansy) and ornamental foliages– Introduction and selection of plants for waterscaping and xeriscaping.

Practical

Description of botanical features– Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Chadha KL & Choudhury B.1992. *Ornamental Horticulture in India*. ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Chaudhary RC. 1993. *Introduction to Plant Breeding.* Oxford & IBH.

Singh BD. 1990. *Plant Breeding*. Kalyani.

FLA 502 Production Technology of Cut Flowers 2+1

Objective

To impart basic knowledge about the importance and production technology of cut flowers grown in India.

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

UNIT II

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering.

UNIT III

Flower production – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.

UNIT IV

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT V

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops

Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages and fillers.

Practical

Botanical description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings

Arora JS. 2006. *Introductory Ornamental horticulture*. Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

Chadha KL & Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.52

Lauria A &Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S &Misra RL. 2007. *HightechFloriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 503 Production Technology for Loose Flowers 2+1

Objective

To impart basic knowledge about the importance and management of loose flowers grown in India.

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques

UNIT II

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

UNIT III

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

UNIT IV

Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packing and storage, value addition, concrete and essential oil extraction, trasportation and marketing, export potential, institutional support, Agri Export Zones. **Crops:** Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Suggested Readings

Arora JS. 2006.*Introductory Ornamental Horticulture*. Kalyani.

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

BoseTK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash. 53

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.* Naya Prokash.

FLA 504 Land Scaping and Ornamental Gardening 2+1

Objective

Familiarization with principles and practices of landscaping and ornamentalgardening.

Theory

UNIT I

Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, informal and free style gardens.

UNIT II

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates.

UNIT III

Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants.

UNIT IV

Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves.

UNIT V

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Selection of ornamental plants**,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nambisan KMP.1992. *Design Elements of Landscape Gardening*. Oxford & IBH.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sabina GT & Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.

Valsalakumari et al. 2008. *Flowering Trees*. New India Publ. Agency.

Woodrow MG.1999. *Gardening in India.* Biotech Books.

FLA 505 Protected Floriculture 2 + 1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation.

UNIT II

Environment control – management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

UNIT III

Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM.

UNIT IV

Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

Practical

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, postharvest handling, packing methods, project preparation, visit to commercial greenhouses.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK & Yadav LP. 1989. *Commercial Flowers.* Naya Prokash.

Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping.*Naya Prokash.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Nelson PV. 1978. *Green House Operation and Management*. Reston Publ. Co.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram B, Balaji T, Kulkarni S &Misra RL. 2007. *Hightech Floriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 506 Value Addition in Flowers 2+1

Objective

To develop understanding of the scope and ways of value addition in flowers.

Theory

UNIT I

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.

UNIT II

Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.;

Selection of containers and accessories for floral products and decorations.

UNIT III

Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.

UNIT IV

Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

Practical

Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc.; Visit to dry flower units, concrete and essential oil extraction units.

Suggested Readings

Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Chadha KL.1995. *Advances in Horticulture*. Vol.XII. Malhotra Publ. House.

Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Reddy S, Janakiram B, Balaji T, Kulkarni S &Misra RL. 2007.*HightechFloriculture.* Indian Society of Ornamental Horticulture, New Delhi.

FLA 507 Turfing and Turf Management 2+1

Objective

To develop understanding of the principles and management of turfing.

Theory

UNIT I

Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT II

Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens.

UNIT III

Preparatory operations; Growing media used for turf grasses – Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT IV

Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Practical

Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics.

Suggested Readings

Nick-Christians 2004. *Fundamentals of Turfgrass Management*. www.amazon.com

Chadha KL & Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR.

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House.

Lauria A &Ries VH. 2001. *Floriculture – Fundamentals and Practices.* Agrobios.

Prasad S & Kumar U. 2003. *Commercial Floriculture.* Agrobios.

Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India.* Allied Publ.

Sheela VL. 2007. *Flowers in Trade*. New India Publ. Agency.

Valsalakumari PK, Rajeevan PK, Sudhadevi PK & Geetha CK. 2008.*Flowering Trees*. New India Publ. Agency.

Note : For minor courses please refer the concerned department's courses outline.

SUPPORTING COURSES

STAT 502 (STATISTICAL METHODS FOR APPLIED SCIENCES) (3+1)

Aim of the course: This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Topics in Theory:

Unit I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Topics in Practical:

- Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal.
- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F.
- Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

Suggested Readings:

- Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
- Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
- Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
- Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.
- Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
- Anderson TW. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed . John Wiley
- http://freestatistics.altervista.org/en/learning.php
- http://www.statsoft.com/textbook/stathome.html

STAT 511 (EXPERIMENTAL DESIGNS) (3+1)

For M.Sc. (Ag.) Agronomy, M.Sc. (Hort.) Vegetable Science, M.Sc. (Hort.) Fruit Science, M.Sc. (Hort.) Plantation, Spices, Medicinal and Aromatic Plants, M.Sc. (Hort.) Floriculture and Landscape Architecture, M.Sc. (Ag.) Soil Science, M.Sc. (Ag.) Genetics and Plant Breeding, M.Sc. (Ag.) Plant Pathology, M.Sc. (Ag.) Entomology, M.Sc. (Ag.) Molecular Biology and Biotechnology.

Aim of the course: This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Topics in Theory:

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Topics in Practical:

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
- Analysis with missing data,
- Split plot and strip plot designs.

Suggested Readings:

- Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.

- Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
- Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.
- Federer WT. 1985. Experimental Designs. MacMillan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
- www.drs.icar.gov.in.

STAT 512 (BASIC SAMPLING TECHNIQUES)

For M.Sc. (Ag.) Agricultural Extension Education and M.Sc. (Ag.) Agricultural Economics

Aim of the course: This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Topics in Theory:

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

Topics in Practical:

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling
- Estimation using ratio and regression estimators
- Estimation using multistage design, double sampling.

Suggested Readings:

- Cochran WG. 1977. Sampling Techniques. John Wiley.
- Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication

NON CREDIT COURSES

PGS 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical: Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey;

Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective: To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;

- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);

- Writing of abstracts, summaries, précis, citations, etc.;

- Commonly used abbreviations in the theses and research communications;

- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;

- Writing of numbers and dates in scientific write-ups;

- Editing and proof-reading;

- Writing of a review article;

- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);

• Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;

• Accentual pattern: Weak forms in connected speech;

• Participation in group discussion;

• Facing an interview;

• Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.

2. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

3. Collins' Cobuild English Dictionary. 1995.

4. Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.

5. Holt, Rinehart and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.

6. James HS. 1994. Handbook for Technical Writing. NTC Business Books.

7. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.

8. Mohan K. 2005. Speaking English Effectively. MacMillan India.

9. Richard WS. 1969. Technical Writing.

10. Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.

11.Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective: The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge based economy.

Theory:

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.

4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

5. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House. 7. The Indian Acts - Patents Act, 1970 and amendments;

8. Design Act, 2000; Trademarks Act, 1999;

9. The Copyright Act, 1957 and amendments;

10. Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003;

11. The Biological Diversity Act, 2002.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective: To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

• Safety measures while in Lab;

• Handling of chemical substances;

• Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;

• Washing, drying and sterilization of glassware;

• Drying of solvents/ chemicals;

• Weighing and preparation of solutions of different strengths and their dilution; • Handling techniques of solutions;

• Preparation of different agro-chemical doses in field and pot applications;

• Preparation of solutions of acids;

• Neutralisation of acid and bases;

• Preparation of buffers of different strengths and pH values;

• Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;

• Electric wiring and earthing;

• Preparation of media and methods of sterilization;

• Seed viability testing, testing of pollen viability;

• Tissue culture of crop plants;

• Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective: To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty

and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.

2. Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.

3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.

4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PROGRAMME-16

Ph.D.

AGRON 601 Current Trends in Agronomy 3+0

Objective

To acquaint the students about recent advances in agricultural production.

Theory

UNIT I

Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship.

UNIT II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures.

UNIT III

Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

UNIT IV

GIS, GPS and remote sensing for crop management, global warming, GMcrops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

UNIT V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

Suggested Readings

Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.

Dahiya BS & Rai KN. 1997. *Seed Technology*. Kalyani.

Govardhan V. 2000. *Remote Sensing and Water Management in ommand Areas: AgroecologicalProspectives*. IBDC.

ICAR. 2006. *Hand Book of Agriculture*. ICAR.

Gupta US. 1988. *Progress in Crop Physiology*. Oxford and IBH.

Kramer PJ & Boyer JS. 1995. *Water Relations of Plant and Soils.* Academic Press.

Mukherjee S & Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.

Narwal SS, Politycka B & Goswami CL. 2007. *Plant Physiology: Research Methods.* Scientific Publishers.

AGRON 605 IrrigationManagement 2+1

Objective

To teach students about optimization of irrigation in different crops under variable agroclimatic conditions.

Theory

UNIT I

Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

UNIT II

Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

UNIT III

Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

UNIT IV

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

UNIT V

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

UNIT VI

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles
- Moisture extraction pattern of crops
- Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity
- Crop planning at the farm and project level
- Agronomic evaluation of irrigation projects, case studies

Suggested Readings

FAO. 1984. *Irrigation Practice and Water Management.* Oxford & IBH.

Michael AM. 1978. *Irrigation: Theory and Practice*.Vikas Publ.

Mishra RR & Ahmad M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.

Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

AGRON 606 Advances in Weed Management 2+0

Objective

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

UNIT I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects.

UNIT II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

UNIT III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.

UNIT IV

Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.

UNIT V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

UNIT VI

Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical herbicide bioassays.

Suggested Readings

Aldrich RJ & Kramer R.J. 1997. *Principles in Weed Management.* Panama Publ.

Ashton FM & Crafts AS. 1981. *Mode of Action of Herbicides*. 2nd Ed. Wiley-Inter Science.

Gupta OP. 2000. *Weed Management – Principles and Practices.* Agrobios.

Mandal RC. 1990. *Weed, Weedicides and Weed Control - Principles and Practices*. Agro-Botanical Publ.

Rao VS. 2007. *Principles of Weed Science*. Oxford & IBH.

Ross MA & CarolaLembi A. 1999. *Applied Weed Science.* 2nd Ed. Prentice Hall.

Subramanian SAM & Kumar R.J. 1997. *All About Weed Control*. Kalyani.

Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic Press.

AGRON 607 Integrated Farming Systems for Sustainable Agriculture 2+0

Objective

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

Theory

UNIT I

Farming systems: definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II

Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III

Production potential of different components of farming systems; interaction and mechanism of different production factors; stability

indifferent systems through research; eco-physiological approaches to intercropping.

UNIT IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.

UNIT V

New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Suggested Readings

Ananthakrishnan TN. (Ed.) 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Balasubramanian P & Palaniappan SP 2006. *Principles and Practices of Agronomy*. Agrobios.

Joshi M & Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.

Lampin N. 1990. *Organic Farming*. Farming Press Books.

Palaniappan SP & Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.

Panda S C. 2004. *Cropping systems and Farming Systems*. Agribios.

Reddy M V. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.

Sharma AK. 2001. *A Hand Book of Organic Farming*. Agrobios.

Singh SP. (Ed) 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.

Trivedi RN. 1993. *A Text Book of Environmental Sciences*. Anmol Publ.

Veeresh GK, Shivashankar K & Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture*. Association for Promotion of Organic Farming, Bangalore.

Venkata Rao BV. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*. Publ. 3. Parisaraprajna Parishtana, Bangalore.

AGRON 608 Soil Conservation and Watershed Management 2+1

Objective

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Theory

UNIT I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

UNIT II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

UNIT IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

UNIT V

Drainage considerations and agronomic management; rehabilitation of abandoned *jhum*lands and measures to prevent soil erosion.

Practical

- Study of different types of erosion
- Field studies of different soil conservation measures

- Run-off and soil loss measurements
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to a soil conservation research centre, demonstration and training centre

Suggested Readings

Arakeri HR & Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.

Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.

FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.,* Paper 57.

Frederick RT, Hobbs J, Arthur D & Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection*. 3rd Ed. Prentice Hall.

Gurmel Singh, Venkataraman CG, Sastry B & Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Murthy VVN. 1995. *Land and Water Management Engineering*. Kalyani.

Tripathi RP & Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.

Yellamanda Reddy T & Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

Note : For minor courses please refer the concerned department's courses outline.

Practical

Estimation of multiple regression model - GLS estimation methods – testingmis specification errors – Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probitmodels - comparing two regressions - Chow test - estimation of distributed lagmodels – panel data random and fixed effects models - Indirect least squares2SLS, SURE, 3SLS, estimation of simultaneous equation models

Suggested Readings

Greene WH. 2002. *Econometric Analysis*. Pearson Edu.

Johnston J & Dinardo J. 2000. *Econometric Methods*. McGraw-Hill.

Kelejan HH & Oates WE. 2001. *Introduction to Econometrics Principles and Applications*. Harper & Row.

Maddala GS. 2002. *Econometrics.* McGraw Hill.

AG ECON 604 Advance Production Economics 2+1

Objective

To expose the students to the concept, significance and uses of advance production economics.

Theory

UNIT I

Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning methods/procedures in agro-economic research and planning.

UNIT II

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance Production relations, optimality, Commonly used functional forms, nature, properties, limitations, estimation and interpretation linear, Spillman Cobb Douglas, quadratic, multiplicative (power)functional forms - Translog and transcendental functional forms-CES, production functional forms, Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic

optimum -Economic optimum, determination of economic optimum with constant and varying input and output prices- Economic optimum with production function analysis - input use behaviour.

UNIT III

Decision making with multiple inputs and out puts, MRT and product relationship-cost of production and adjustment in out put prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk Cost of wrong decisions, Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions, Principles and derivation of demand and supply functions .

UNIT IV

Technology, input use and factor shares -effect of technology on input use decomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production – technical, allocative and economic efficiency –measurement Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.

UNIT V

Simulation and programming techniques in agricultural production-Multiple Course Objective Programming – Goal programming and Compromise programming, applications.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-Optimal product and input choice under multi input and output system Estimation of factor shares from empirical functions estimated Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology-Estimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming MOTAD-

Quadratic programming Simulation models for agricultural production decisions. Goal programming, Weighted, lexicographic and fuzzy goal programming. Compromise programming.

Suggested Readings

Chambers RG. 1988. *Applied Production Analysis*. Cambridge Univ. Press.

Gardner BL & Rausser GC. 2001. *Handbook of Agricultural Economics*. Vol. IA *Agricultural Production.* Elsevier.

Palanisami KP, Paramasivam & Ranganathan CR. 2002. *Agricultural Production Economics: Analytical Methods and Applications*. Associated Publishing Co.

AG ECON 605 QuantitativeDevelopment Policy Analysis

Objective

- The course trains the Scholars in the art of informed decision making and helps them to appreciate the value of the analytical basis in policy decisions.
- They are given hands on training on the estimation and use of variouscriteria such as elasticities in making QDPA more meaningful
- The scholars make extensive reviews to get acquainted with the analytical
- relevance and in drawing inferences.

Theory

UNIT I

Policy framework, goals, value, beliefs and welfare maximization. Market, Policy and State, State vs. Market Failure of Policy, Failure of Markets, Rationale for Government Intervention. Role of Quantitative Policy Analysis.

UNIT II

Demand analysis for policy making, Alternative approaches to demand analysis Policy implications. Supply response, Alternative approaches to measurement of supply response, Nerlovian models of supply response, Policy implications.

Meier MG & Stigilitz JE. 2001. *Frontiers of Development Economics-the Future Perspective*. Oxford Univ. Press.

Sadoulet E & de Janvry A. 1995. *Quantitative Development Policy Analysis*. London: John Hopkins Univ. Press.

Shoven Neck R, Christian R & Mooslechner P. (Eds.). 2008. *Quantitative Economic Policy Essays in Honour of Andrew Hughes Hallett.*

AG ECON 606 Advance Agricultural Marketing and Price Analysis

Objective

The main Course Objective of this course is to critically analyze the important marketing concepts, models, properties of agricultural commodity prices and forecasting, data collection and analysis using current software etc., in order to make them policy decisions in the field of agricultural marketing.

Theory

UNIT I

Importance of market analysis in the agricultural system, types of marketing advantages and disadvantages - quantitative estimation, the distinguishing
characteristics and role of agricultural prices, data sources for agricultural products and prices - softwares used in market analysis.

UNIT II

Role of various formal institutions in agricultural marketing and functions measuring their efficiency, public, private partnership, institutional arrangements. Successful case studies.

UNIT III

Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the changing agri food system.

UNIT IV

Agricultural commodity marketing - spot and futures- marketing of derivatives-speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets-Regulatory mechanism of futures trading.

UNIT V

Lag operators and difference equations; stationary and stochastic processes; UNIT roots and cointegration; conditional heteroscedasticity:ARCH and GARCH models - forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

Practical

Estimation of demand/ supply forecasting, supply chain / value chain analysis for different commodities - Commodity models- multi market estimation- time series analysis - market integration studies- price discovery price volatility estimation - commodity price forecasting using econometric softwares.

Suggested Readings

Ferris JN. 1998. *Agricultural Prices and Commodity Market Analysis*. McGraw-Hill.

Goodwin JW. 1994. *Agricultural Price Analysis and Forecasting*. Wiley.

Hallam D. 1990. *Econometric Modeling of Agricultural Commodity Markets*. New Routledge.

Martimort D. (Ed.). 1996. *Agricultural Markets: Mechanisms, Failures, and Regulations*. Elsevier.

Schrimper RA. 2001. *Economics of Agricultural Markets*. Pearson.

Timmer CP. 1986. *Getting Prices Right*. Cornell University Press.

Tomek WG & Robinson KL. 2003. *Agricultural Product Prices*. 4th Ed. Cornell University Press.

Note : For minor courses please refer the concerned department's courses outline

ENT 605 Insect Behaviour 1+1

Objective

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behaviour in insects.

Theory

Unit I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.

Unit II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

Unit III

Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Self organization and insect behaviour.

Unit IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, coevolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; sensorydaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect(DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honeybees/*Helicoverpaarmigera*to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

Suggested Readings

Ananthkrishnan TN. (Ed.). 1994. *Functional Dynamics of Phytophagous Insects*. Oxford & IBH, New Delhi.

Awasthi VB. 2001. *Principles of Insect Behaviour*. Scientific Publ., Jodhpur.

Bernays EA & Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects*. Chapman & Hall, London.

Brown LB. 1999. *The Experimental Analysis of Insect Behaviour.* Springer, Berlin.

Krebs JR & Davies NB. 1993. *An Introduction to Behavioural Ecology.* 3rd Ed. Chapman & Hall, London.

Manning A & Dawkins MS. 1992. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.

Mathews RW & Mathews JR. 1978. *Insect Behaviour.* A Wiley- Inter Science Publ. John Wiley & Sons, New York.

ENT 606 Recent Trends in Biological Control 1+1

Objective

To appraise the students with advanced techniques in handling of different bioagents, moder nmethods of biological control and scope in cropping system-based pest management in agroecosystems.

Theory

Unit I

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations.

Unit II

Mass culturing techniques, insectary facilities and equipments, basic standards of insectary,viable mass-production unit, designs, precautions, good insectary practices.

Unit III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, largescale production of biocontrol agents, bankable project preparation.

Unit IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit /insectary.

Suggested Readings

Burges HD & Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

Coppel HC & James WM. 1977. *Biological Insect Pest Suppression.* Springer Verlag, Berlin.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman & Hall, London.

Dhaliwal, GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.

Gerson H & Smiley RL.1990. *AcarineBiocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.

Huffakar CB & Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.

ENT 607 Advance Insecticide Toxicology 2+1

Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

Unit I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides.

Unit II

Biochemical and physiological target sites of insecticides in insects; developments inbiorationals, biopesticides and newer molecules; their modes of action and structural –activity relationships; advances in metabolism of insecticides.

Unit III

Joint action of insecticides; activation, synergism and potentiation.

Unit IV

Problems associated with pesticide use in agriculture: pesticide resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

Unit V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards, and good agricultural practices.

Practical

Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects.

Suggested Readings

Busvine JR. 1971. *A Critical Review on the Techniques for Testing Insecticides.* CABI, London.

Dhaliwal GS & Koul O. 2007. *Biopesticides and Pest Management.* Kalyani Publ., New Delhi.

Hayes WJ & Laws ER. 1991. *Handbook of Pesticide Toxicology.* Academic Press, New York.

Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.

O' Brien RD. 1974. *Insecticides Action and Metabolism.* Academic Press, New York.

Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.

Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publ., New York.

ENT 608 Advanced Host Plant Resistance 1+1

Objective

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory

Unit I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

Unit II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylicacid pathways; effects of induced resistance; exogenous application of elicitors.

Unit III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

Unit IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, ovipositio*etc.*, allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/planthoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index,antibiosis index, tolerance index, plant resistance index.

Suggested Readings

Panda N. 1979. *Principles of Host Plant Resistance to Insects*. Allenheld, Osum & Co., New York.

Rosenthal GA & Janzen DH. (Eds.). 1979. *Herbivores – their Interactions with Secondary Plant Metabolites*.Vol.I, II. Academic Press, New York.

Sadasivam S & Thayumanavan B. 2003. *Molecular Host Plant Resistance to Pests*. Marcel Dekker, New York.

Smith CM, Khan ZR & Pathak MD. 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*.CRC Press, Boca Raton, Florida.

Practical

Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gelelectrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Readings

Bhattacharya TK, Kumar P & Sharma A. 2007. *Animal Biotehnology*. 1st Ed., Kalyani Publ., New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG & Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.

Oakeshott J & Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Rechcigl JE & Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests*. Lewis Publ., North Carolina.

Roy U & Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publ., NewDelhi.

Singh BD. 2008. *Biotechnology (Expanding Horizons)*.Kalyani Publ., New Delhi.

Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publ., New Delhi.

ENT 612 AdvancedIntegrated Pest Management 2+0

Objective

To acquaint the students with recent concepts of integrated pest management. Surviellance and data base management. Successful national and international case histories of integrated pest management, non conventional tools in pest management.

Theory

Unit I

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling.

Unit II

Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests.

Unit III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' real time situations.

Unit IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Suggested Readings

Dhaliwal GS & Arora R. 2003. *Integrated Pest Management– Concepts and Approaches.* Kalyani Publ., New Delhi.

Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology.* Kalyani Publ., New Delhi.

Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management.* Springer, Berlin.

Koul & Cuperus GW. 2007. *Ecologically Based Integrated Pest Management.* CABI, London.

Koul O, Dhaliwal GS & Curperus GW. 2004. *Integrated Pest Management-Potential, Constraints and Challenges.* CABI, London.

EXT 601 Advances in Agricultural Extension 2+1

UNIT I

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.

UNIT II

Cyber Extension - Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension - Farmer - Market linkage: Importance, Scope, Implications etc., Market - Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership, Stakeholder's analysis in Extension, Main streaming gender in Extension - Issues and Prospects.

UNIT III

Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension.

UNIT IV

Extension and contemporary issues: Extension and issues related to rural poverty, Privatization of Extension, Intellectual Property Rights (IPRs). Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups, Organization innovations in Extension - ATIC, IVLP, Kisan Call Centers.

Practical

Analysis of ITK systems, cases on integration of ITK and formal research system, Analysis of cases on cyber extension and privatization of extension, Analysis of ATMA and SREP, Practicing bottom up planning. Visit to Public-Private –Farmer partnership, Leanings from Food and Nutritional Security and bio-diversity Projects and Programmes.

Suggested Readings

Bagchi J. 2007. *Agriculture and WTO Opportunity for India*. Sanskruti.

Chambers R, Pacy A & Thrupp LA. 1989. *Farmers First*. Intermediate Technology Publ.

Crouch BR & Chamala S. 1981. *Extension Education and Rural Development*. Macmillan.

John KC, Sharma DK, Rajan CS & Singh C. 1997. *Farmers Participation in Agricultural Research and Extension Systems*. MANAGE, Concept Publ.Co.

Khan PM. 2002. *Text Book of Extension Education*. Himanshu Publ.

Narasaiah ML. 2005. *Agricultural Development and World Trade Organization*. Discovery Publ.

Talwar S. 2007. *WTO Intellectual Property Rights*. Serials Publ.

Van den Ban BW & Hawkins BS. 1998. *Agricultural Extension*. S.K. Jain Publ.

Venkaiah S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

EXT 602 Advanced Designs and Techniques in Social Science Research 2+1

UNIT I

Scaling technique - meaning, types, principles, steps and quality, techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive Intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Reliability and Validity of

Scales, Sociometrics, content analysis, case studies, Q-sort techniques, Semantic different technique.

UNIT II

Projective and Semi projective techniques, Critical incident techniques, Computer packages for analysis - usage in Extension Research, Knowledge scale measurement, Participatory tools and techniques in behaviour Research – Data collection and Evaluation, Impact analysis, e-data collection and information analysis.

Practical

Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques, Content analysis, case studies, practicing participatory tools and techniques. Hands on experience on Computer Preparation and Data Collection instruments, review of previous studies.

Suggested Readings

Burns RB. 2000. *Introduction to Research Methods*. Sage Publ.

Chandrakandan K & Karthikeyan C. 2004. *Behavioral Research Methodology*. Classical Publ.

Daivadeenam P. 2002. *Research Methodology in Extension Education*. Agro-TechPubl. Academy.

Kerlinger N Fred. 2002. *Foundations of Behavioural Research*. Surjeet Publ.

Kothari CR. 2000. *Research Methodology Methods & Techniques*. 2nd Ed. Wishwa Prakasham.

Ray GL & Mondal S. 1999. *Research Methods in Social Science and Extension Education*. Naya Prokash.

Roger L & Domino WSK. 1980. *Research Methods*. Prentice Hall.

Sadhu AM & Singh A. 2003. *Research Methodology in Social Science*. Himalaya Publ. House.

Sarantakos S. 1998. *Social Research*. 2nd Ed. Macmillan.

Sinha SC & Dhiman AK. 2002. *Research Methodology*. ESS Publ.

Verma RK & Verma G. 2002. *Research Methodology*. Commonwealth Publ.

Walizer MH & Panl L. 2002. *Research Methods & Analysis; Searching for Relationships.* Wiemil Harper & Row.

Wilkinson TS & Bhandarkar PL. 2002. *Methodology and Techniques of Social Research*. Himalaya Publ. House.

EXT 607 Advanced Management Techniques 2+1

Theory

UNIT I

Management Information System (MIS): Basic concepts, types of information needed at various levels, design of MIS in an agricultural extension organization, Scope for computerization, system alternatives and Evaluation, Implementation, operation and maintenance of the system.

UNIT II

Management by Course Objective (MBO): Elements of the MBO system, The Process of MBO. Making MBO effective, Evaluation of the MBO system - strengths and weaknesses, Transactional Analysis (TA): Ego states, transactions, inter relationships, strokes, stamps.

UNIT III

Managing Organizational Stress: Sources of stress in organization, effect of stress. Coping mechanisms and managing stress, Stress management, Team Building Process: Types of teams, Steps in teamwork, Facilitators and barriers to effective relationships, nature of prejudice, tips in reducing interpersonal conflicts, intergroup conflict, resolving techniques, Conflict management, tips in reducing interpersonal conflicts.

UNIT IV

Decision Support Systems (DSSs): Basic information about Artificial Intelligence(AI) Expert System (ESs), their future applications in

extension system. Forecasting techniques - time series analysis and Delphi, decision making and talent management PERT, CPM Techniques and time management.

Practical

Managements Information system, in research & development organizations, Study of Management by Course Objective in an organization, Transactional Analysis, exercises on Team building process, coping skills with organizational stress, exercises on Decision Support Systems (DSSs),Practical exercise on forecasting techniques, Visit to Management organizations.

Suggested Readings

Chaudhary AK. 1999. *Encyclopedia of Management Information System.* Vols. I, II. Anmol Publ.

Hari Gopal K. 1995. *Conflict Management - Managing Interpersonal Conflict*. Oxford & IBH.

James O'Brien 1999. *Management Information System*. Tata McGraw-Hill.

Koontz H & Welhrich H. 2004. *Essentials of Management*. 5th Ed. Tata. McGraw-Hill.

Lauden & Lauden 2003. *Management Information System*. Pearson Edu.

Maheswari BL. 1980. *Organizational Decision Styles & Orgul Effectiveness*. Vikas Publ.

McGrath SJEH. 2007. *Basic Management Skills for All*. 7th Ed. Prentice Hall of India.

West JD & Leevy FK. 1998. *A Management Guide to PERT / CPM with GERT /PDM / DCPM and Other Networks*. Prentice Hall of India.

EXT 603 Advances in Training Technology 2+1

Theory

UNIT I

Paradigm shift in training - learning scenario, Training Approaches – Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, harmonizing training needs, Course Objective, content and methods.

UNIT II

Designing an effective training session - the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees).

UNIT III

Recent Training Techniques for understanding and facilitation team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training, Psychological instruments as training tools:

TAT, Inventories, Cases, etc.

UNIT IV

Participatory Training Techniques - Lecture, Brainstorming, Group discussion and Training Games. Role Play, Psycho-drama, Coaching, Counseling, etc., Trainer's roles and dilemmas, Factors Effecting Training Effectiveness and Training Evaluation.

Practical

Techniques of participatory training need assessment. Formulation of Course Objective, design of training programmes, Simulation exercises, Participatory training methods - Role Play & Brainstorming, Group discussion and Counseling and Conducting experiential learning sessions, Training evaluation - Techniques of Knowledge, Skill &

Attitude evaluation. Visit to training institutions and study of training technologies followed.

Suggested Readings

Agochiya D. 2002. *Every Trainer's Handbook*. Sage Publ.

Alan B & Calardy 2004. *Five Case Studies in Management Training*. Jaico Publ.

Kumar A. 2000. *Management Training Process.* Anmol Publ.

Leslie Rae. 1998. *Techniques of Training*. Jaico Publ.

Lynton RP & Pareek U. 1999. *Training for Development*. 2nd Ed. Vistar Publ.

Reid MA. 1997. *Training Interventions, Managing Employee Development*. Jaico.Publ.

Samanta RK. 1993. *Training Methods for Management and Development*. M.D.Publ.

Sethy ED. 2003. *A Practical Hand Book on Training*. Anmol Publ.

EXT 604 Organizational Development 2+1

Theory

UNIT I

Introduction to organizations: Concept and Characteristics of organizations, Organizational Behvaiour - Context and concept - levels of organizations – formal and informal organizations, Theories of organizations: Nature of organizational theory - classical theories - features of Bureaucracy - administrative theory and Scientific management - Neo-classical theories - the human relations movement - modern theory.

UNIT II

Systems approach to study organization needs and motives - Attitude, values and ethical behaviour - alienation and work - work motivation - communication and interpersonal behaviour - organization communication - leadership behaviour - decision making, problem

Dwivedi RS. 2006. *Human Relations and Organization Behaviour- A Global Perspective*. 5th Ed. Macmillan.

Kumar A. 2000. *Organizational Behaviour Theory and Practice*. Anmol Publ.

Luthans F. 1998. *Organizational Behavior*. Tata McGraw Hill.

Luthans F. 2001. *Organizational Behaviour*. McGraw Hill.

Newstrom JW & Davis K. 1997. *Human Behaviour at Work*. Tata McGraw Hill.

Robbins SP. 2007. *Organizational Behaviour*. Prentice Hall.

Shaun T & Jackson T. 2003. *The Essence of Organizational Behaviour*. Practice Hall of India.

Stephen RR. 1999. *Organizational Behaviour*. 5th Ed. Practice Hall of India.

EXT 609 Transfer of Technology in Agriculture 2+1

Theory

UNIT I

Technology - Meaning and Concepts - Appropriate technology, transfer of technology - meaning and concepts, Systems of transfer of technology - Knowledge Generating System (KGS) - Knowledge Disseminating System (KDS) - Knowledge Consuming System (KCS) - Input Supplying Agencies System (ISAS).

UNIT II

Appropriateness of communication media in the system of technology transfer, New communication strategy for transfer and adoption of Agricultural technology, Extension training in transfer of technology.

UNIT III

Analysis, Constraints in Transfer of Technology, agencies or departments involved in TOT, Extension professional in TOT, Attributes of Technology and its Relation in TOT process. TOT to resource poor farmers, Role of Key communicators or local leaders in TOT, Private and Public partnership in TOT.

Practical

Analysis of Transferred technology, Analysis of knowledge generation and consuming systems, Formulation of communication strategies, Study of attributes of selected fast spreading technologies and slow technologies, study of constraints in TOT, visit to TOT centers of ICAR and SAU, Identification of key communicators, Case studies of Public-Private Partnerships, Visits to the print and electronic media centers to study their role in TOT.

Suggested Readings

Chaturvedi TN. 1982. *Transfer of Technology among Developing Countries; Needfor Strengthening Cooperation*. Gitanjali Publ. House.

Dunn DD. 1978. *Appropriate Technology with a Human Face.* Macmillan Press.

Kapoor SK, Roy PB & Roy AK. 1980. *Role of Information Centers in Technology Transfer*. IASLIC, Kolakata.

Lekhi RK. 1984. *Technological Revolution in Agriculture*. Classical Publ. Co.

Singh SN. 1991. *Transfer of Technology to Small Farmers. An Analysis of Constraints and Experience*. Concept Publ. Co.

Wallender HW. 1980. *Technology Transfer of Management in the Developing Countries*. Ballinger Publ. Co., Cambridge.

Note: For minor courses please refer the concerned department's courses outline.

GP 601 Plant Genetic Resources and Pre-Breeding 2+0

Objective

To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.

Theory

UNIT I

Historical perspectives and need for PGR conservation; Importance of plantgenetic resources; Taxonomical classification of cultivated plants; Genepool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes.

UNIT II

Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation.

UNIT III

Germplasm conservation- *in situ, ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources.

UNIT IV

PGR data base management; Multivariate and clustering analysis, descriptors; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets.

UNIT V

Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and

21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality.

UNIT VI

Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of transferred genes and their expression.

UNIT VII

Post-genomic tools for genetic enhancement of germplasm; Prebreeding through chromosome manipulation; Application of biotechnology for Genetic enhancement-Achievements.

UNIT VIII

Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement/Prebreeding for crop improvement including hybrid development.

Suggested Readings

Frankel OH & Bennett E. 1970. *Genetic Resources in Plants – their Exploration and Conservation*. Blackwell.

Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. *Plant Germplasm Collecting: Principles and Procedures*. NBPGR, New Delhi.

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.

Paroda RS & Arora RK. 1991. *Plant Genetic Resources, Conservation and Management. Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.

Puzone L & Hazekamp TH. 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.

Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

Singh RJ & Jauhar PP. 2005. *Genetic Resources, Chromosomal Engineering and Crop Improvement*. Vol. I. *Grain Legumes*, Vol. II. *Cereals*. CRC Press, Taylor & Francis Group, USA.

GP 602 Advanced Biometrical and Quantitative Genetics 2+1

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes.

UNIT II

Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis.

UNIT III

Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model -Biplots and mapping genotypes.

UNIT IV

Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance – Construction of saturated linkage maps, concept of framework map development; QTL mapping- Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) -

Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical

Working out efficiency of selection methods in different populations and interpretation Biparental mating use of softwares in analysis and result interpretation Triallel analysis use of softwares in analysis and result interpretation Quadriallel analysis use of softwares in analysis and result interpretation Triple Test Cross (TTC) use of softwares in analysis and result interpretation Advanced biometrical models for combining ability analysis Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model Principal Component Analysis model - Additive and multiplicative model Shifted multiplicative model - Analysis and selection of genotypes Methods and steps to select the best model - Selection systems Biplots and mapping genotypes. Construction of linkage maps and QTL mapping Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Suggested Readings

Bos I & P Caligari. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.

Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.

Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.

Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.

Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.

Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GP 603 Genomics in Plant Breeding 2+1

Objective

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory

UNIT I

Introduction to the plant genome- Plant nuclear genomes and theirmolecular description - The chloroplast and the mitochondrial genomes inplants - Genome size and complexity.

UNIT II

Establishment of plant genome mapping projects Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III

Regulation of Plant gene expression - Functional genomics – Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV

Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics–Genome Comparison Techniques- Classical and advanced approaches.

UNIT V

Detection of Single Nucleotide Polymorphism; TILLING and Eco-TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI

Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization Comparative genomic hybridization Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers – QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases Comparative genomics Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING – DNA Array Technology Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

Baxevanis AD & Ouellette BFF. 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* Wiley Interscience.

Brown TA. 2002. *Genomes*. Wiley-LISS.

Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.

Cantor CR & Smith CL (2004). *Genomics*. Wiley, New York.

Galas DJ & McCormack SJ. 2002. *Genomic Technologies: Present and Future*. Calster Academic Press.

Lal R & Lal S. (Eds.). 1990. *Crop Improvement Utilizing Biotechnology*. CRC Press.

Mantel SH & Smith H. 1983. *Plant Biotechnology*. Cambridge University Press.

Sen SK & Giles KL. (Eds.). 1983. *Plant Cell Culture in Crop Improvement*. Plenum Press.

GP 605 Advances in Plant Breeding Systems 2+0

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Facts about plant breeding before the discovery of Mendelism; Evolutionary concepts of genetics and plant breeding - Flower development and its importance; genes governing the whorls formation and various models proposed; Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination.

UNIT II

Self- incompatability and sterility Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility: male and female sterility Types of male sterility: genic, cytoplasmic and cytoplasmic-genic; Exploitation in monocots and dicots, difficulties in exploiting CGMS system in dicots – Case studies and breeding strategies; Nucleocytoplasmic interactions with special reference to male sterility – Genetic , biochemical and molecular bases.

UNIT III

Population formation by hybridization Types of populations Mendelian population, gene pool, composites, synthetics etc.; Principles and procedures in the formation of a complex population; Genetic basis of population improvement.

UNIT IV

Selection in self fertilizing crops; Creation of genetic variability selection methods - Selection methods: mass selection, pureline selection, pedigree method (selection in early generations vs advanced generations); Backcross, polycross and test cross.

UNIT V

Selection in cross fertilizing crops – Polycross and topcross selections, Mass and recurrent selection methods and their modifications – Mass selection: grided mass selection, ear to row selection, modified ear to rowselection; Convergent selection, divergent selection; Recurrent selection:Simple recurrent selection and its modifications (restricted phenotypicselection, selfed progeny selection and full sib recurrent selection), Recurrent selection for general combining ability (GCA), Concepts and utilization - Recurrent selection for specific combining ability (SCA) –usefulness in hybrid breeding programmes - Reciprocal recurrent selection(Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities.

UNIT VI

Genetic engineering technologies to create male sterility; Prospects and problems - Use of self- incompatability and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programmes, Conversion of agronomically ideal genotypes into male steriles, Concepts and breeding strategies; Case studies -Generating new cytonuclear interaction system for diversification of male steriles, Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genic

Male Sterility (EGMS), Types of EGMS; Influence on their expression, genetic studies; Photo and thermosensitive genetic male sterility and its use in heterosis breeding, Temperature sensitive genetic male sterility and its use heterosis breeding, Apomixis and its use in heterosis breeding. Incongruity, Factors influencing incongruity - Methods to overcome incongruity mechanisms.

Suggested Readings

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.

Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.

Briggs FN & Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.

Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.

Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.

Mandal AK, Ganguli PK & Banerji SP. 1995.*Advances in Plant Breeding*. Vol.I, II.CBS.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.

Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani.

Singh P. 1996. *Essentials of Plant Breeding*. Kalyani.

Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

GP 608 Advances in Breeding of Major Field Crops 3+0

Objective

To provide insight into recent advances in improvement of cereals, millets and non cereal crops using conventional and modern biotechnological approaches.

Theory

UNIT I

History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum, Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.

UNIT II

Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT III

Breeding for value addition and resistance to abiotic and biotic stresses.

UNIT IV

Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT V

National and International accomplishments in genetic improvement ofmajor field crops and their seed production.

Suggested Readings

Chopra VL. 2001. *Breeding Field Crops - Theory and Practice*. Oxford & IBH.

Ulloa M & Hanlin RT. 2000. *Illustrated Dictionary of Mycology*. APS, St. Paul, Mennisota.

Webster J & Weber R. 2007. *Introduction to Fungi*. Cambridge Univ. Press, Cambridge.

PL PATH 602 Advanced Virology 2+1

Objective

To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory

UNIT I

Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultra structural changes due to virus infection, variation, mutation and virus strains.

UNIT II

Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodiesin identification of viruses and their strains, Polymerase Chain Reaction.

UNIT III

Genome organization, replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-, poty-, bromo, cucummo, ilar and tospoviruses.

UNIT IV

Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions.

UNIT V

Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI

Techniques and application of tissue culture. Origin, evolution and inter relationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii)DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance, nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

Suggested Readings

Davies 1997. *Molecular Plant Virology: Replication and Gene Expression*. CRC Press, Florida.

Fauquet*et al*. 2005. *Vius Taxonomy*. VIII Report of ICTV. Academic Press, New York.

Gibbs A & Harrison B. 1976. *Plant Virology - The Principles.* Edward Arnold, London.

Jones P, Jones PG & Sutton JM. 1997. *Plant Molecular Biology: Essential Techniques*. John Wiley & Sons, New York.83

Khan JA & Dijkstra. 2002. *Plant Viruses as Molecular Pathogens*. Howarth Press, New York.

Maramorosch K, Murphy FA & Shatkin AJ. 1996. *Advances in Virus Research*. Vol. 46. Academic Press, New York.

Pirone TP & Shaw JG. 1990. *Viral Genes and Plant Pathogenesis.* Springer Verlag, New York.

Roger Hull 2002. *Mathew's Plant Virology* (4th Ed.). Academic Press, New York.

Thresh JM. 2006. *Plant Virus Epidemiology.* Advances in Virus Research 67. Academic Press, New York.

Stacey G & Keen TN. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

PL PATH 605 Principles and Procedures ofCertification1+0

Objective

To acquaint with certification procedures of seed and planting material.

Theory

UNIT I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control.

UNIT II

Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health etc.

UNIT III

Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. Methods used in certification of seeds, vegetative propagules and *in vitro* cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

Suggested Readings

Association of Official Seed Certifying Agencies. http://www.aosca.org/index.htm.

Hutchins D & Reeves JE. (Eds.). 1997. *Seed Health Testing: Progress Towards the 21st Century*. CABI, UK.

ISHI-v*eg Manual of Seed Health Testing Methods.* http://www.worldseed.org/enus/international_seed/ishi_vegetable. html ISHI-F *Manual of Seed Health Testing Methods*.

Magdoff F & Weil RR 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.

Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture.* John Wiley & Sons.

Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.

Stevenson FJ. 1994. *Humus Chemistry – Genesis, Composition and Reactions.* John Wiley & Sons.

SOILS 602 Advances in Soil Fertility 2+0

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

UNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III

Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils.

UNIT IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity underlong-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings

Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.

Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.

Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.

Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.

Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC/ Taylor & Francis.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. *Micronutrients in Agriculture.* 2nd Ed. Soil Science Society of America, Madison.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*.John Wiley & Sons.

Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers.* 5th Ed. Macmillan Publ.

Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed. Longman.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.

Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*.Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*.Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.

Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOIL 604 Soil Genesis and Micropedology 2+0

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

UNIT I

Pedogenic evolution of soils; soil composition and characterization.

UNIT II

Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals.

UNIT III

Assessment of soil profile development by mineralogical and chemical analysis.

UNIT IV

Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Suggested Readings

Boul SW, Hole ED, Mac Craken RJ & Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.

Brewer R. 1976. *Fabric and Mineral Analysis of Soils.*John Wiley & Sons.

SOIL 601 Advances in Soil Physics 2+0

Objective

To provide knowledge of modern concepts in soil physics.

Theory

UNIT I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.

UNIT II

Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy'slaw in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one-dimensional water flow.

UNIT III

Theories of horizontal and vertical infiltration under different boundary conditions.

UNIT IV

Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

UNIT V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil.

UNIT VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in agriculture.

UNIT VII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.

Hanks and Ascheroft. 1980. *Applied Soil Physics*. Springer Verlag.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Environmental Soil Physi*cs. Academic Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.

Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

SOIL 606 Land use Planning and Watershed Management 2+0

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

UNIT I

Concept and techniques of land use planning; factors governing present land use.

UNIT II

Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT III

Agro-ecological regions/sub-regions of India and their characteristics inrelation to crop production.

UNIT IV

Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity.

UNIT V

Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.

FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.

Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.

Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8th Ed. USDA & NRCS, Washington, DC.

USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

SOIL505 Soil Erosion and Conservation 2+1

Objective

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

UNIT I

History, distribution, identification and description of soil erosion problems in India.

UNIT II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; Rainfall erosivity - estimation as EI_{30} index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

UNIT III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

UNIT IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

UNIT V

Soil conservation planning; land capability classification; soil conservationin special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

- Determination of different soil erodibility indices - suspension percentage,
- dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio,
- percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI_{30}) using rain gauge data
- Visits to a watersheds

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Note: For minor courses please refer the concerned department's courses outline.

FSC 601 advances in breeding of fruit crops 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of fruit crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits , recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

Crops

UNIT I : Mango and banana

UNIT II: Papaya, grapes and citrus

UNIT III: Guava and sapota

UNIT IV: Pineapple and avocado

UNIT V: Apple, pear, plums, peaches, apricot, cherries and strawberry

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination-isozyme techniques-survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

Suggested Readings

Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.

Chadha KL & Pareek OP. (Eds.). 1996. *Advances in Horticulture*. Vol. I. Malhotra Publ. House.

Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.

Gowen S. 1996. *Banana and Plantains*. Chapman & Hall.

Janick J & Moore JN. 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons.

Nijjar GS. (Ed.). 1977. *Fruit Breeding in India*. Oxford & IBH.

Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture*. Jagmander Book Agency.

Stover RH & Simmonds NW. 1991. *Bananas*. Longman.

FSC 602 Advances in Production of Fruit Crops 2+1

Objective

To keep abreast with latest developments and trends in production technology of fruit crops.

Theory

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling , Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, , Total quality management(TQM) - Current topics.

Crops

UNIT I : Mango and banana

UNIT II: Papaya, grapes and citrus

UNIT III: Guava, sapota, pomegranate and aonla

UNIT IV: Pineapple, avocado, jack fruit and fig

UNIT V: Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency- estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis.

Suggested Readings

Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. *Temperate Fruits – Horticulture*. Allied Publ.

Bose TK, Mitra SK & Sanyal D. (Eds.). 2001. *Fruits -Tropical and Subtropical*. Naya Udyog.

Bose TK, Mitra SK, Farooqi AA & Sadhu MK. 1999. *Tropical Horticulture.* Vol. I. Naya Prokash.

Chadha KL & Pareek OP. (Eds.). 1996. *Advances in Horticulture*. Vols. IIIV. Malhotra Publishing House.

Chadha KL. 2001. *Handbook of Horticulture*. ICAR.

Nakasone HY & Paull RE. 1998. *Tropical Fruits*. CABI.

Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

FSC 603 Advances in Growth Regulation of Fruit Crops 2+1

Objective

Appraisal on the advances in growth regulation of fruit crops.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.

Fosket DE. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press.

Leoplod AC & Kriedermann PE. 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill.

Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press.

Salisbury FB & Ross CW. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

FSC 507 Post Harvest Technology for Fruit Crops 2+1

Objective

To facilitate deeper understanding on principles and practices of postharvest management of fruit crops.

Theory

UNIT I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT III

Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storageventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.

UNIT V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, cold chain management - visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Suggested Readings

Bhutani RC. 2003. *Fruit and Vegetable Preservation*. Biotech Books.

Chadha KL & Pareek OP. (Eds.). 1996. *Advances in Horticulture*. Vol. IV. Malhotra Publ. House.

Haid NF & Salunkhe SK. 1997. *Post Harvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.

Mitra SK. 1997. *Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits*. CABI.

Ranganna S. 1997. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.

Sudheer KP & Indira V. 2007. *Post Harvest Technology of Horticultural Crops*. New India Publ. Agency.

Willis R, Mc Glassen WB, Graham D & Joyce D. 1998. *Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. CABI.

FSC 605 Biotic and Abiotic Stress Management in Horticultural Crops 2+1

Objective

To update knowledge on the recent research trends in the field of biotic and abiotic stress management in horticultural crops.

Theory

UNIT I

Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

UNIT II

Pollution - increased level of CO2, industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.

UNIT III

Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

UNIT IV

Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.

UNIT V

Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

Practical

Seed treatment /hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll flurosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.

Suggested Readings

Blumm A. 1988. *Plant Breeding for Stress Environments*. CRC.

Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments.* Wiley Inter. Science.

Gupta US. 1990. *Physiological Aspects of Dry Farming*.

Hsiao TC. 1973. Plant Responses to Water Stress. *Ann. Rev. Plant Physiology* 24:519-570.

Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

Levitt J. 1972. *Response of Plants to Environmental Stresses*. Academic Press.

Maloo SR. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy.

Mussell H & Staples R. 1979. *Stress Physiology in Crop Plants*. Wiley Inter. Science.

Nickell LG. 1983. *Plant Growth Regulating Chemicals*. CRC.

Peter KV. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency.

Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

Note : For minor courses please refer the concerned department's courses outline.

VSC 601 Advances in Vegetable Production 2+1

Objective

To keep abreast with latest developments and trends in production technology of vegetable crops.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT I : Tomato, brinjal, chilli, sweet pepper and potato

UNIT II : Cucurbits, cabbage, cauliflower and knol-khol

UNIT III :Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV :Carrot, beet root and radish

UNIT V : Sweet potato, tapioca, elephant foot yam and taro

Practical

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices; dry land techniques for rainfed vegetable production; production constraints;

analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis ; marketing survey of the above crops; visit to vegetable and fruit mals and packing houses.

Suggested Readings

Bose TK & Som NG. 1986. *Vegetable Crops of India*. Naya Prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.

Brewster JL. 1994. *Onions and other Vegetable Alliums*. CABI. FFTC. *Improved Vegetable Production in Asia*. Book Series No. 36.

Ghosh SP, Ramanujam T, Jos JS, Moorthy SN & Nair RG. 1988. *Tuber Crops*. Oxford & IBH.

Gopalakrishnan TR. 2007. *Vegetable Crops*. New India Publishing Agency.

Kallo G & Singh K. (Ed.). 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.

Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S & Pallai SV. 1996. *Tropical Tuber Crops, Problems, Prospects and Future Strategies*. Oxford & IBH.

Sin MT & Onwueme IC. 1978. *The Tropical Tuber Crops*. John Wiley & Sons.

Singh NP, Bhardwaj AK, Kumar A & Singh KM. 2004. *Modern Technology on Vegetable Production*. International Book Distr. Co.

Singh PK, Dasgupta SK & Tripathi SK. 2006. *Hybrid Vegetable Development*. International Book Distr. Co.

VSC 602 Advances in Breeding of Vegetable Crops 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of:

UNIT I : Tomato, brinjal, chilli, sweet pepper and potato

UNIT II : Cucurbits, Cabbage, cauliflower and knol-khol

UNIT III : Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV : Carrot, beet root and radish

UNIT V : Sweet potato, tapioca, elephant foot yam and taro

Practical

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Suggested Readings

Acta Horticulture. Conference on Recent Advance in Vegetable Crops. Vol. 127.

Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.

Chadha KL. 2001. *Hand Book of Horticulture*. ICAR.

Dhillon BS, Tyagi RK, Saxena S & Randhawa GJ. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.

Janick JJ. 1986. *Horticultural Science*. 4th Ed. WH Freeman & Co.

Kaloo G & Singh K. 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals and Book Publ. House.

Kaloo G. 1994. *Vegetable Breeding*. Vols. I-III. Vedams eBooks.

Peter KV & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised Ed.). ICAR.

Ram HH. 2001. *Vegetable Breeding*. Kalyani.

VSC 603 Protected Cultivation of Vegetable Crops 1+1

Objective

To impart latest knowledge in growing of vegetable crops under protected environmental condition.

Theory

Crops: Tomato, capsicum, cucumber, melons and lettuce

UNIT I

Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT II

Regulatory structures used in protected structures; types of greenhouse / polyhouse / nethouse, hot beds, cold frames, effect of environmental factors, *viz.* temperature, light, CO2 and humidity on growth of different vegetables, manipulation of CO2, light and temperature for vegetable production, fertigation.

UNIT III

Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT IV

Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, weet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT V

Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

Practical

Study of various types of structures, methods to control temperature, CO2 light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/polyhouse/net house/shade house in the region.

Suggested Readings

Anonymous 2003. *Proc. All India Seminars on Potential and Prospects for Protective Cultivation*. Organised by Institute of Engineers, Ahmednagar. Dec.12-13, 2003.

Chandra S & Som V. 2000. *Cultivating Vegetables in Green House. Indian Horticulture* 45: 17-18.

Prasad S & Kumar U. 2005. *Greenhouse Management for Horticultural Crops*. 2nd Ed. Agrobios.

Tiwari GN. 2003. *Green House Technology for Controlled Environment*. Narosa Publ. House.

VSC 604 Biotechnologies in Vegetable Crops 2+1

Objective

To teach advances in biotechnology for improvement of vegetable crops.

Theory

Crops: Tomato, eggplant, hot and sweet pepper, potato, cabbage, cauliflower, tapioca, onion, cucurbits.

UNIT I

In vitro culture methods and molecular approaches for crop improvement in vegetables, production of haploids, disease elimination in horticultural crops, micro grafting, somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion; construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement, improvement for biotic and abiotic stresses, transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, finger printing of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids; Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods, molecular characterization of transgenic plants.

VSC 605 Seed Certification, Processing and Storage of Vegetable Crops 2+1

Objective

To educate the recent trends in the certification, processing and storage of vegetable crops.

Theory

UNIT I

Seed certification, objectives, organization of seed certification, minimum seed certification standards of vegetable crops, field inspection, specification for certification.

UNIT II

Seed processing, study of seed processing equipments seed cleaning and upgrading, Seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number.

UNIT III

Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control.

UNIT IV

Seed testing; ISTA rules for testing, moisture, purity germination, vigor test, seed sampling, determination of genuineness of varieties, seed viability, seed health testing; seed dormancy and types of dormancy, factors responsible for dormancy.

UNIT V

Seed marketing, demand forecast, marketing organization, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy.

Practical

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of

seed testing equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

Suggested Readings

Agrawal PK & Dadlani M. 1992. *Tecniques in Seed Science and Technology*. South Asian Publ.

Singh N, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distr. Co.

Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

Tanwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, GOI, New Delhi.

Rajan S & Baby L Markose 2007. *Propagation of Horticultural Crops.* New India Publ. Agency.

VSC 606 Abiotic Stress Management in Vegetable Crops 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

UNIT I

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of antitranspirants.

UNIT II

Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III

Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V

Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

Suggested Readings

Dwivedi P & Dwivedi RS. 2005. *Physiology of Abiotic stress in Plants.* Agrobios.

Lerner HR (Ed.). 1999. *Plant Responses to Environmental Stresses.* Marcel Decker.

Maloo SR. 2003. *Abiotic Stresses and Crop Productivity*. Agrotech Publ. Academy.

Note : For minor courses please refer the concerned department's course outline.

Suggested Readings

Cochran WG. 1977. *Sampling Techniques*. John Wiley.

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.

Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods.* IASRI Publ.

Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

SUPPORTING COURSE OF PH.D. (AG./HORT.)

1. STAT 521/ APPLIED REGRESSION ANALYSIS 2+1

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

UNIT I

Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

UNIT II

Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis;

Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.

UNIT IV

Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and theirm applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Suggested Readings

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.

Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. *Applied Regression Analysis and Multivariable Methods*. Duxbury Press.

Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.

Kutner MH, Nachtsheim CJ & Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

2. STAT 531/ DATA ANALYSIS USING STATISTICAL PACKAGES 2+1

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students an hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III

Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV

Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way analysis of variance , contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Readings

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.

Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.

Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.

Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis*. Chapman & Hall.

NON-CREDIT COURSES FOR PG/Ph.D. DEGREE PROGRAMME

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.) Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective

- To equip the students/scholars with skills to write dissertations, research papers, etc.
- To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental

results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS 1+0

(e-Course) MANAGEMENT IN AGRICULTURE

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual

Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographicalindications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.

Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

PGS 506 DISASTER MANAGEMENT 1+0

(e-Course)

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: Global warming, Sea level rise, Ozone depletion.

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response: Police and other organizations.

Suggested Readings

Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.

Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.

AGRONOMY

Course Title : Current Trends in Agronomy

Course Code :Agron 601

Credit Hours : 3+0

Aim of the course

To acquaint the students about recent advances in agricultural production.

Theory

Unit I

Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant managementMechanizationin crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Recent advances in agricultural production

Suggested Reading

• Agarwal RL. 1995. Seed Technology. Oxford & IBH.

• Dahiya BS and Rai KN. 1997. Seed Technology. Kalyani.

• Govardhan V. 2000. Remote Sensing and Water Management in Command Areas: AgroecologicalProspectives. IBDC.

• ICAR. 2006. Hand Book of Agriculture. ICAR.

• Narasaiah ML. 2004. World Trade Organization and Agriculture. Sonali Publ.

• Palaniappan SP and Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.

• Sen S and Ghosh N. 1999. Seed Science and Technology. Kalyani.

• Tarafdar JC, Tripathi KP and Kumar M. 2007. Organic Agriculture Scientific Publ.

• Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. A Text Book of Seed Technology. Kalyani Publication.

• Reddy SR and Prabhakara G. 2015. Dryland Agriculture. Kalyani Publishers.

• Gururajan B, Balasubhramanian R and Swaminath V. 2013. Recent Strategies on Crop Production. Kalyani Publishers.

• Venkateswarlu B and ShankerArun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy 54(2): 226-230.

Course Title : Recent Trends in Crop Growth and Productivity

Course Code :Agron 602

Credit Hours : 2+1

Aim of the course

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

• Field measurement of root-shoot relationship in crops at different growth stages

• Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth

• Computation of harvest index of various crops

• Assessment of crop yield on the basis of yield attributing characters

• Construction of crop growth curves based on growth analysis data

• Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping

• Senescence and abscission indices

• Analysis of productivity trend in un-irrigated areas

• Analysis of productivity trend in irrigated areas

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of crop growth for agricultural production

Suggested Reading

• Chopra VL and Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford & IBH.

• Delvin RM and Vitham FH. 1986. Plant Physiology. CBS Publ.

• Evans LT. 1975. Crop Physiology. Cambridge Univ. Press.

• Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.

• Gupta US. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.

• Gupta US. 1988. Progress in Crop Physiology. Oxford & IBH.

• Kramer PJ and Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.

• Mukherjee S and Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.

• Narwal SS, Politycka B and Goswami CL. 2007. Plant Physiology: Research Methods. Scientific Pub.

• Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

Course Title : Irrigation Management

Course Code :Agron 603

Credit Hours : 2+1

Aim of the course

To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

Theory

Unit I

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit VIII

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit IX

Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit X

Crop water production function

Practical

• Determination of water infiltration characteristics and water holding capacity of soil profiles.

• Determination Moisture extraction pattern of crops

• Determination of water balance component of transplanted rice by drum culture technique

• Determination of consumptive use and water requirement of a given cropping pattern

• Determination of crop efficient of one important crop

• Planning, designing and installation of drip irrigation system

• Planning, designing and installation of sprinkler irrigation system

• Designing of drainage channel

• Measurement of irrigation efficiencies

• Determination of irrigation timing under different methods of irrigation

• Visit to irrigation command area

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Management of irrigation water for sustainable agriculture

Suggested Reading

• MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers

• FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.

• Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.

• Mishra RR and Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.

• Panda SC. 2003. Principles and Practices of Water Management. Agrobios.

• Reddy SR. 2000. Principles of Crop Production. Kalyani.

• Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.

• Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH

Course Title : Recent Trends in Weed Management

Course Code :Agron 604

Credit Hours : 2+0

Aim of the course

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors

affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Suggested Reading

• Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.

• Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi)

• Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.

• Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.

• Jugulan M, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press • Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley

• Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.

• Walia US. 2006. Weed Management, Kalyani.

• Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub

Title : Research and Publication Ethics

Course Code :Agron 608

Credit Hours : 0+2

Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatorypublishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to checkpublisher copy right and selfarchivingpolicies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open sourcesoftware tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, field practicals and laboratory visit.

Learning outcome

Developed skill for research management, quality publication

Note : For minor courses please refer the concerned department's courses outline.

Learning outcome

After successful completion of the course, the student will be able to- Understand the different market competition. Work out strategies for attaining equilibrium in the market.

Suggested Reading

• Henderson JM and Quandt RE. Microeconomic Theory: A Mathematical Approach Tata McGraw Hill Publishing Co Ltd
• Koutsoyiannis A. Modern Micro Economics. Macmillan Press Ltd
• Ferguson and Gould. Micro Economic Theory. Richard D Erwin Inc USA

Course Title : Advanced Macro Economics
Course Code : AEC-602
Credit Hours : 2+0

Why this course?

A deeper understanding of the conceptual and structural framework is imperative to develop vision of a student about how the knowledge of various macroeconomic models is applied in real economy.

Aim of the course

To understand the functioning of national economy, its history and models. The policies governing the modern economic system and concerned institutions.

Organization of the course

The course is organised as follows–

No Block	Unit
1. Introduction	1. Overview
2. Economic Models	1. Open Economy Models
	2. Dynamic Macroeconomic Models
3. Business cycle and pollicies	1. Business Cycles
	2. Macroeconomic Polices

Theory

Block 1- Introduction

Unit 1: Overview Conceptual framework - Classical, Keynesian, Neo-Classical, and Neo-Keynesian macroeconomics; Review of Keynes-Classical Synthesis; Aggregate Demand and Supply in the closed economy with fixed

and variable price level- determination of wage, prices, output and employment

Block 2- Economic Models

Unit 1:Open Economy Models

Exchange rate determination; purchasing power parity; asset market approach; Short-run open economy models; Mundell-Fleming model- exchange rate regime: perfect capital mobility under fixed and flexible exchange rate; effectiveness of fiscal policy and monetary policy; Dornbusch's overshooting model; monetary approach to balance of payments; international financial markets

Unit 2: Dynamic Macroeconomic Models

Introduction to dynamic macroeconomic Models; Dynamic aggregate demand and supply – short and long term equilibrium- rational expectations approach

Block 3: Business Cycle and Policies

Unit 1:Business Cycles

Business cycle and its alternative equilibrium model, Stability analysis Economics of Great Events-Depression, Hyperinflation and Deficits; Advances in Business Cycle Theory; Real Business Cycles & Neo-Keynesian Economics

Unit 2: Macroeconomic Polices

Monetary policy - Design of Monetary Policy; Inflation Targeting, Fiscal Policy - Government Budget Constraint: The Arithmetic of Deficits and Debt, Current versus Future Taxes, the Evolution of Debt-to-GDP Ratio; Public Borrowing-Internal and external aid, Deficit financing, Development Financing; BOP & Adjustment Policies - Foreign Exchange Policy - International macro-economic policies, IMF, IBRD, UNCTAD.

Teaching Methods/ Activities

• Lectures. • Case studies. • Assignments (Group/individual). • Group Discussions

Learning outcome

After successful completion of this course the student will be able to-Figure out how policies are framed to safe guard the national economy. Understand the rationale behind the working of different economy.

Suggested Reading

• Heibroker RL. Understanding Macro Economics.

• Mehta JK. Macro Economics. • Edgemand MR. Macro-Economics: Theory & Policy.
• David' W Pearce. The dictionary of modern Economics.
• Allen RGD. 1968. Macro–Economic Theory: A Mathematical Treatment. London: Macmillan.
• Stanlake GF. Macro–Economics: An Introduction. Longman, London.
• Mithai DM. 1981. Macro–Economics: Analysis and Policy. Oxford and IBH, New Delhi. • Hicks JR Critical Essays in Monetary Theory.
• Nawiyn WT. Theory of Money.

Course Title : Advanced Econometrics

Course Code : AEC 603

Credit Hours : 2+1

Why this course?

The heart of any research is carrying out the analysis with the most appropriate model. The results obtained are crucial for the researchers. Thus, this course acts as the centre point of building up analytical framework of research. The students need to learn building up of models that will be used to test the hypothesis framed. Use different analysis depending upon the requirement and type of data.

Aim of the course

The course aims at providing the knowledge and command over analysis of data collected to get the desired result. Train the student in use of econometric models.

Organization of the course

The course is organised as follows:

No Block	Unit
1. Concepts	1. Review
2. Least squares and dummy variables	1. Concept of Least Squares 2. Dummy Variable
3. Econometric models	1. Models and their extensions 2. Simultaneous equation modles

Theory

Block 1: Concepts

Unit 1: Review

Review of classical regression model – review of hypothesis testing – restrictions Social Sciences: Agricultural Economics 219 on parameters – single equation techniques.

Block 2: Least Squares and Dummy Variables

Unit 1: Concept of least squares

Ordinary least squares – weighted least squares - generalized least squares – method of principal components – instrumental variables method - maximum likelihood method - errors in variables, non-linearity and specification tests – non spherical error terms.

Unit 2: Dummy Variable

Dummy variables - Qualitative and truncated dependent variables - limited dependent variables –LPM, probit and logit models, their multinomial extensions.

Block 3: Econometric Models

Unit 1: Models and their extensions

Autoregressive distributed lag models – panel data fixed and random effects models and their extensions.

Unit 2: Simultaneous equation models

Simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS

Practical

Estimation of multiple regression model - GLS estimation methods - testing misspecification errors – Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probit models - comparing two regressions - Chow test - estimation of distributed lag models – panel data random and fixed effects models - Indirect least squares 2SLS, SURE, 3SLS, estimation of simultaneous equation models.

Teaching Methods/ Activities

• Lectures. • Case studies. • Assignments (Group/ individual). • Group Discussions

Learning outcome

After successful completion of the course, the student will be able to– • Analyse the data collected for testing the framed hypothesis. • Get expertise in analytical framework.

Suggested Reading

• Greene WH. 2002. Econometric Analysis. Pearson Education. • Johnston J and Dinardo J. 2000. Econometric Methods. Mc Graw-Hill. • Koutseyianis A. 1997. Theory of Econometrics. Barner& Noble.

Course Title : Advanced Production Economics
Course Code : AEC 604
Credit Hours : 2+1
Why this course?
There is requirement of getting acquainted with decision making process in case of factors and products. The researcher needs to understand about working on production process and work out suitable suggestions to improve it.
Aim of the course
The course deals with the concept of advanced production economics. The exposition would be mathematically oriented. The course would also cover the analysis of production functions, its interpretation, decision making with multiple input use, factor sharing and decision making under risk and uncertainty.
Organization of the course
The course is organised as follows:

No Block	Unit
1. Consumer Theory	1. Production Process
2. Market and General quilibrium	1. Production Functions and characteristics
3. Market failure and welfare	1. Decision Making in Production 2. Technology, Efficiency and Risk Management 3. Programming

Theory
Block 1: Production process
Unit 1: Production Process
Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning-methods/ procedures in agro-economic research and planning.
Block 2: Production Function
Unit 1: Production Functions and characteristics

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity,, APP, MPP, elasticities of substitution and their economic relevance – Production relations – optimalityCommonly used functional forms, nature, properties, limitations, estimation and interpretation - linear, Spillman - Cobb Douglas, quadratic, multiplicative (power) functional forms - Translog, and transcendental functional forms - CES, production functional forms-Conceptual and empirical issues in specification, estimation and application of production functions-Analytical approaches to economic optimum - Economic optimum – determination of economic optimum with constant and varying input and output prices - Economic optimum with production function analysis - input use behaviour.

Block 3: Dynamics of production process

Unit 1: Decision Making in Production

Decision making with multiple inputs and outputs – MRT and product relationship cost of production and adjustment in output prices-single input and multiple product decisions- Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions - Cost curves – Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions

Unit 2: Technology, Efficiency and Risk Management

Technology, input use and factor shares -effect of technology on input usedecomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement -Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.

Unit 3: Programming

Simulation and programming techniques in agricultural production-Multiple Objective Programming (MOP) – Goal programming, Weighted sum and Compromise programming – applications.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations-

Optimal product and input choice under multi input and output system-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technologyEstimation of efficiency measures – Stochastic, probabilistic and deterministic frontier production functions-Risk programming – MOTAD-Quadratic programmingSimulation models for agricultural production decisions-Goal programming – Weighted, lexicographic and fuzzy goal programming-Compromise programming.

Teaching Methods/ Activities

• Lectures. • Case studies. • Assignments (Group/individual). • Group Discussions

Learning outcome

After successful complétion of the course, the student will be able to-Get familiar with different production function and use them in practise and come out with useful decision. Work out the efficiency of the production process and use models for finding the optimum solution.

Suggested Reading

• Baumol WG. 1973. Economic theory and operations analysis. Practice Hall of India Private Limited, New Dehli. 626 p. • Gardner BL and Rausser GC. 2001. Handbook of Agricultural Economics Vol. I Agricultural Production. Elsevier. • Heady EO. 1952. Economics of Agricultural Production and resources use. Practice Hall of India. • Heady EO and Dillon JL. 1961. Agricultural Production functions. Kalyani Publishers, Ludhiana, India. 667 p.

Note : For minor courses please refer the concerned department's courses outline

ENTOMOLOGY

Course Title : Insect Phylogeny and Systematics

Course Code : ENT 601

Credit Hours : 3 (1+2)

Aim of the course

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. Detailed study about the International Code of Zoological Nomenclature; ethics and procedure for taxonomic publications.

Theory

Unit I

Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

Unit II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

Unit III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.

Unit IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular sytematics.

Practical

• Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group;

• Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation, Submission of the collections made of the group;

• Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms;

• Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

Learning outcome

• Scholars are expected to understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity; prepare taxonomic keys for specific groups and write taxonomic papers and reviews.

• Scholars should be able to identify insects of economic importance up to family/ generic levels and specialize in any one group of insects up to species level identification.

Suggested Reading

CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca. Dakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer-Verlag, Berlin. Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi. Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA. Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York. Mayr E and Ashlock PD. 1991. Principles of Systematic Zoology. 2nd Ed. McGraw Hill, New York. Mayr E.1969. Principles of Systematic Zoology. McGraw-Hill, New York. Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London. Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London. Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.

Course Title : Insect Physiology and Nutrition
Course Code : ENT 602
Credit Hours : 3 (2+1)
Aim of the course
To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones, etc.
Theory
Unit I
Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.
Unit II
Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.
Unit III
Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.
Unit IV
Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.
Practical
• Preparation of synthetic diets for different groups of insects;
• Rearing of insects on synthetic, semi-synthetic and natural diets;
• Determination of co-efficient of utilization;

• Qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph;
• Zymogram analyses of amylase;
• Determination of chitin in insect cuticle;
• Examination and count of insect haemocytes.

Learning outcome

• The scholars are expected to have thorough theoretical and practical knowledge of insect physiology that can be made use of in practical/ applied entomological aspects.
• Understand how physiological systems in insects are integrated to maintain homeostasis.

Suggested Reading

Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London. Kerkut GA and Gilbert LI. 1985. Insect Physiology, Biochemistry and Pharmacology. Vols. IXIII. Pergamon Press, Oxford, New York.
Muraleedharan K. 1997. Recent Advances in Insect Endocrinology. Association for Advancement of Entomology, Trivandrum, Kerala.
Rockstein, M. 1978. Biochemistry of Insects, Academic Press. Simpson, SJ. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.

Course Title : Insect Ecology and Diversity
Course Code : ENT 603
Credit Hours : 3 (2+1)
Aim of the course

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

Theory

Unit I

Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie

Course Title : Bio-inputs for Pest Management
Course Code : ENT 605
Credit Hours : 3 (2+1)
Aim of the course
To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.
Theory
Unit I
Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-à-vis target pest populations.
Unit II
Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bioagents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.
Unit III
Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.

Unit IV
Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in bio-control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.
Practical
• Mass rearing and release of some commonly occurring indigenous natural enemies;
• Assessment of role of natural enemies in reducing pest populations;
• Testing side effects of pesticides on natural enemies;
• Effect of semio-chemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests;

• Project document preparation for establishing a viable mass-production unit/ insectary;
• Observation of feeding behavior acts of predatory bugs/ beetles.

Learning outcome

• Scholars are expected to learn the mass multiplication techniques of the more common and economically feasible natural enemies to be exploited under IPM programmes.
• They should be able to guide entrepreneurs for establishing a viable massproduction unit/ insectary.

Suggested Reading

Burges HD and Hussey NW. (Eds.). 1971. Microbial Control of Insects and Mites. Academic Press, London. Coppel HC and James WM. 1977. Biological Insect Pest Suppression. Springer Verlag, Berlin. De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, London. Dhaliwal, GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publishers, New Delhi. Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman and Hall, New York. Huffakar CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London. Restructured and Revised Syllabi of Post-graduate Programmes Vol. 1 206

Course Title : Insecticide Toxicology and Residues

Course Code : ENT 606

Credit Hours : 3 (2+1)

Aim of the course

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

Unit I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

Unit II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

Unit III

Joint action of insecticides; activation, synergism and potentiation.

Unit IV

Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

Unit V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.

Practical

• Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods;

• Calculations and interpretation of data;

• Biochemical and biological techniques for detection of insecticide resistance in insects;

• Preparation of EC formulation using neem oil.

VII. Learning outcome

• Scholars are expected to be well versed with the latest technologies of bioassays, insecticide/ pesticide residue analysis and solving problems associated with insect resistance to insecticides.

VIII. Suggested Reading

Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London. Dhaliwal GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publishers, New Delhi. Hayes WJ and Laws ER. 1991. Handbook of Pesticide Toxicology. Academic Press, New York. Plant Protection–Entomology 207 Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi. Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York. O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York. Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in

Agriculture and Environment. Narosa Publ. House, New Delhi. Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.

Course Title : Plant Resistance to Insects
Course Code : ENT 607
Credit Hours : 2 (1+1)
Aim of the course
To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.
Theory
Unit I
Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species – gene pool; insect sources – behaviour in relation to host plant factors.
Unit II
Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.
Unit III
Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; markeraided selection in resistance breeding.
Unit IV
Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.
Practical
• Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance; • Macroculturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests; • Field screening-microplot techniques, infester row technique, spreader row technique and plant nurseries; • Determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Learning outcome

• Scholars are expected to identify sources of resistance in different crops and varieties; their utilization in resistance breeding programmes involving screening techniques for specific pests.

Suggested Reading

Panda N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum and Co., New York.
Rosenthal GA and Janzen DH. (Eds.). 1979. Herbivores – their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York. Sadasivam S and Thayumanavan B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York. Smith CM, Khan ZR and Pathak MD. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

Course Title : Integrated Pest Management

Course Code : ENT 610

Credit Hours : 2 (2+0)

Aim of the course

To acquaint the students with recent concepts of integrated pest management; surveillance and data base management; successful national and international case histories of integrated pest management, non-conventional tools in pest management.

Theory

Unit I

Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.

Unit II

Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

Unit III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

Unit IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Learning outcome

• Having gained sufficient experience in advanced studies of IPM the scholars should be able to independently frame IPM schedules for major crops/ cropping ecosystems (cereal/ pulse crop/ oilseed crop based/ vegetable crop based agro-ecosystems).

Suggested Reading

Dhaliwal GS and Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publishers, New Delhi. Dhaliwal GS, Singh R and Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publishers, New Delhi. Flint MC and Bosch RV. 1981. Introduction to Integrated Pest Management. Springer, Berlin. Koul O and Cuperus GW. 2007. Ecologically Based Integrated Pest Management. CABI, London. Koul O, Dhaliwal GS and Curperus GW. 2004. Integrated Pest Management –Potential, Constraints and Challenges. CABI, London. Maredia KM, Dakouo D and Mota-Sanchez D. 2003. Integrated Pest Management in the Global Arena. CABI, London. Metcalf RL and Luckman WH. 1982. Introduction to Insect Pest Management. John Wiley and Sons, New York. Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi. Pedigo RL. 1996. Entomology and Pest Management. Prentice Hall, New Delhi. Subramanyam B and Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York

AGRICULTURAL EXTENSION EDUCATION

Course Title : Policy Engagement and Extension

Course Code : EXT 601

Credit Hours : 2+1

Why this course?

Extension's performance in any country to a large extent is dependent on the wider policy and institutional context prevailing at the national level. At the organizational level, extension should have capacities to influence policies that affect their performance. To effectively influence policies, extension professionals need to generate not only sound evidence of its impact, but also capacities to engage with policy relevant actors especially at various levels. While few countries have developed specific extension policies, there has been very limited success in translating these policies into programmes and operational guidelines. Lack of policy relevant research to generate evidence on extension's impact; poor documentation of successful initiatives, and lack of training on engaging with policy relevant actors have all contributed to this. Extension professionals, often encounter situations where existing policy constraints development interventions or where new policies could better support development. This course is aimed at developing these capacities to successfully engage with policy actors and bringing about desirable policy changes to strengthen extension.

Aim of the course

• To orient students on the importance of policies in shaping extension's performance • To discuss ways of generating policy relevant evidence to influence policies • To develop capacities to engage with policy actors and the policy development process

The course is organized as follows:

No Blocks	Units
1. Why policies matter?	1. Understanding Policy
	2. Policy Advocacy and Tools
	3. Policy Analysis

	4. Policy Development Process
2. Using evidence to influence	1. Influencing Policy Change Policy Change
	2. Global Experience with Extension Policy

Theory

Block 1: Why Policies Matter?

Unit 1: Understanding Policy

Why policies are important for extension? Role in providing structure, ensure funding and framework for providing functions-examples; Policy: definitions and types: Is policy a product or a process or both? Policies and institutions- How these influence defining organisational roles and performance in extension organizations Role of policies in upscaling knowledge-Role of extension in influencing policies to enable innovation.

Unit 2: Policy Advocacy and Tools

Definition of advocacy, Approaches to policy advocacy-Advising, Media campaigning, Lobbying, Activism, Information Education Communication (IEC) and Behavior Change Communication (BCC); Advocacy for Rural Advisory Services (RAS); Policy advocacy strategy

Unit 3: Policy Analysis

Explain the meaning and use of policy analysis in decision- making; Describe different types of policy analysis- empirical, evaluative or normative policy analysis, retrospective/ prospective policy analysis, predictive/prescriptive/descriptive policy analysis; How to do policy analysis? - understand the process of policy analysis, highlight the different methods and techniques used in policy analysis, doing ethical policy analysis; Tools for policy impact- research tools, context assessment tools, communication tools, policy influence tools

Unit 4: Policy Development Process

Policy development process: Who drives policy change?: National Governments, Donors, Civil Society-varied experiences: Understanding the

environment and key actors in policy space- problem identification-policy adoption, implementation and evaluation; stakeholder mapping, identifying opportunities and barriers, mobilising financial resources; Dealing with policy incoherence: identifying contradictions and challenges in policy implementation

Block 2: Using Evidence to Influence Policy Change

Unit 1: Influencing Policy Change

Generating evidence: Role of policy research; analyzing the usefulness and appropriateness of the evidence; Using evidence in policy advocacy; Understanding your audience: analyzing channels of influence; creating alliances; identifying policy champions; Defining goals and objectives; Developing advocacy messages: Policy papers, Policy briefs, good practice notes, etc.: Good practices in influencing policies Organising policy dialogues: Policy engagement strategy-Engaging with policy makers: GO and NGO experiences; Policy working groups; advisory panels; use of committees: Use of media including ICTs and social media for influencing policies.

Unit 2: Global Experience with Extension Policy

Extension policy in different countries: Explicit extension policy Vs extension as part of Agriculture Policy, Challenges in policy implementation: lack of capacities, financial resources, ownership, lack of stakeholder consultations: Strengthening capacities in extension to influence policies: Global Forum for Rural Advisory Services (GFRAS)'s efforts in strengthening extension policy advocacy: policy compendium, training modules, training for strengthening capacities to influence policies.

Practicals

• Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS • Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation • Interview key policy actors in EAS arena at the state/national level (eg: Director of Agriculture, Director of Extension in SAU, Chairman/Managing Director of Commodity Board. Member Agriculture, State Planning Board) to explore policy level challenges in EAS • Identify what evidence policy makers look for from extension

research? Is the evidence available? If so what form? (Reports, Briefs etc), If not, develop a plan • Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use • Identify policy level bottlenecks that constrain effective EAS delivery at the district level- Eg: Issues around linkages between KVK and ATMA; inter-departmental collaboration; public private partnerships; joint action etc.

Teaching methods/activities

– Lecture – Assignment (Reading/Writing) – Student's Book/Publication Review – Student presentation – Group Work – Student's interview of key policy makers – Case Analysis – Guest Lectures – Review of policy documents – Short attachments

Learning outcome

After successful completion of this course, the students are expected to be able to: – Appreciate the role of policies in shaping performance of extension – Understand how to generate and communicate policy relevant evidence – Critically evaluate extension policies in different countries – How to engage in policy advocacy.

Suggested Reading

AEPF. 2015. Report on the Policy Forum by Ghana Directorate of Agricultural Extension Services, Ministry of Food and Agriculture; Modernizing Extension and Advisory Services and Agriculture Policy Support Project, Ghana. http://www.g-fras.org/en/knowledge/documents/category/18-policy.html?download=490: report-on-the-ghana-agricultural-extension-policy-forum-2015 Amosa, MDU. 2018. Policy Analysis and Engagement Toolkit. A guide for Pacific Non-government Organizations in the Fisheries Sector.WWF. http://d2ouvy59p0dg6k.cloudfront.net/downloads/policy_analysis_toolkit_quality.pdf Anonymous.N.d. Policy analysis. http://www.egyankosh.ac.in/bitstream/123456789/25760/1/Unit-19.pdf Anonymous. N.D. Policy analysis. https://web.csulb.edu/~msaintg/ppa670/670steps.htm Bardach E. A Practical Guide for Policy Analysis The Eightfold Path to More Effective Problem

dER/8RDlh/DJpiqGHeJfRq+6GbXfimIiyR27rnjntLue4IInS63ip3IBqRfUlemI +oBl1SIJ Picciotto. R. 2004. Policy Coherence and Development Evaluation Concepts, Issues and Possible Approaches. OECD. http://www.oecd.org/pcd/31659358.pdf Richard KC.2014. Policy Analysis for Social Workers. Sage Publication. http://dx.doi.org/10.4135/9781544303550 Sharma R.2002. Reforms in Agricultural Extension: New Policy Framework. Economic and Political Weekly. Vol. 37, No. 30 pp. 3124-3131. https://www.epw.in/journal/2002/30/review-agriculture-review-issues-specials/reforms-

agricultural-extension.htmlSprechmann. S and Pelton. E 2001. Advocacy Tools and Guidelines Promoting Policy Change. Cooperative for Assistance and Relief Everywhere, USA. https://onthinktanks.org/wp-content/uploads/2016/01/CARE_Advocacy_Guidelines.pdf Start D and IngieHovland. 2004. Tools for Policy Impact: A Handbook for Researchers. Overseas Development Institute. https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/194.pdf Sulaiman RV and Hall A. 2005. Extension Policy at the National Level in Asia. Plant Production Science Vol 8, 308-319. https://www.tandfonline.com/doi/pdf/10.1626/pps.8.308 Sulaiman RV. 2014. How to Develop and Implement Extension Policies? Lessons from Four Australasian Countries. Global Forum for Rural Advisory Services, Switzerland http://compendium.g-fras.org/component/phocadownload/category/27-checklists-stepwiseapproaches.html?download=263: how-to-develop-and-implement-extension-policies-lessonsfrom-four-australasian-countries The Policy Project. 1999. Networking for Policy Change An Advocacy Training Manual. The Futures Group International, Research Triangle Institute (RTI) and The Centre for Development and Population Activities (CEDPA). http://www.policyproject.com/pubs/AdvocacyManual.pdf

Course Title : Methodologies for Social and Behavioural Research

Course Code : EXT 602

Credit Hours : 2+1

Why this course?

In general, social and behavioural science research plays a crucial role in the professional development in a subject domain, through advancing knowledge and developing working modalities and standards. Precisely, the empirical research helps to develop robust and outcome focused working strategies, processes and models to enable the professionals to maximise their efficiency. This course on advanced social science research caters to the need to equipping the scholars with essential skills in conducting high quality research which helps them to design working strategies, processes and models for professional development.

Aim of the course

This course aims to equip the doctoral students to conduct outcome-oriented social and behavioural science research and to develop sound field focused extension strategies and models with adequate replicability, while advancing knowledge on processes governing success of those strategies. The focus of the course is on equipping the scholars with advanced capacities in conducting systematic, objective and outcome oriented research by applying state-of-art methods and tools at every stage of research from planning to publishing.

The course is organized as follows:

No Blocks	Units
1. Advanced methods for improving quality of research data	1. Measurement Properties of Research Instruments
	2. Threats to Data Quality
2. Scales, indexes and tests	1. Scales, Indexes and Tests-1
	2. Scales, Indexes and Tests-2
3. Emerging research approaches	1. Qualitative Research Methods and designs
	2. Emerging Approaches
4. Utilising research outputs	1. Publishing Research
	2. Ethics in Extension Research

Theory

Block 1: Advanced Methods for Improving Quality of Research Data

Unit 1: Measurement Properties of Research Instruments

Measurement properties – Dimensionality, reliability and validity; Dimensionality – Unidimensionality and multidimensionality, Methods of assessing dimensionality, Formative and reflective constructs; Validity - Importance, Internal validity - face validity; content validity, Substantive Validity, Structural Validity; External validity - Convergent and Discriminant Validity, known-group validity, Criterion-Related Validity, Consequential Validity, nomological validity; Methods of assessing various forms of validities – Judges rating, Lawshe's Content Validity Ratio, Item-objective congruence index; latent variable method; Reliability - Internal consistency reliability – Split-Half, Cronbach alpha; Temporal Stability reliability - test-retest method; Interrater Consistency and Consensus – inter rater reliability and interrater agreement; Alternative Forms or parallel forms reliability – Reliability of difference - Factors Affecting the Validity and Reliability of Test Scores; Generalizability Theory

Unit 2: Threats to Data Quality

Errors and biases; Errors – Meaning and sources; Types - Sampling error, Nonsampling or measurement error and Processing error – Meaning, causes; Effects of errors and biases on data quality; Bias in behavioural research – Meaning, causes, Types – Respondent and researcher biases; Methods of reducing errors and biases in surveys, questionnaires, personal interviews, focus groups and online methods

Block 2: Scales, Indexes and Tests

Unit 1: Scales, Indexes and Tests-1

Approaches to measurement and scale development - Classical test theory. Formative or index models, The C–OAR–SE approach and Item Response Theory; Item analysis in Classical test theory – item difficulty and item discrimination; Scoring performance in scales and tests – meaning, types and methods; Scale development strategies – deductive and empirical; Stimulus-centred scales – method of equally appearing intervals, paired comparison, Person scaling – Q methodology; Subjectcentre scales – The Likert scale and Semantic Differential

Unit 2: Scales, Indexes and Tests-2

Steps in constructing a multi-dimensional scale using confirmatory factor analysis,; Response scales - Guttman'sscalogram analysis and The Rasch method; Indexes –Meaning, types, importance; Similarities anddifferences with scales, Methods of constructing indexes; Common indexes used in extension. Measurement invariance –Meaning, types, methods of assessing measurement invariance. Tests – meaning, types, importance; steps in conducting various tests – knowledge test

Block 3: Emerging Research Approaches and Designs

Unit 1: Qualitative Research Methods

Qualitative methods – Meaning; Types – Ethnography, Grounded theory, Phenomenology, Ecological psychology, Discourse Analysis; Observational research; Case study research – Sampling and sample size; Data collection methods - Indepth interviews, Focus groups, Direct observation, Record review; Content analysis; Unobtrusive Measures; Projective and semi-projective techniques; Selecting right qualitative method – Strengths and limitations of qualitative research; Analysis and interpretation of qualitative research data; Research synthesis – meaning, importance, methods; Systematic reviews and meta analysis – meaning, steps, and applications; Policy research

Unit 2: Emerging Approaches

Mixed methods research – meaning, purpose, types and applications; Participatory research – Meaning, importance, types, methods and tools and applications; Action research – Meaning, importance, Principles, Types, Steps in conducting action research, application in behavioural sciences. Social Network Analysis – Meaning, importance, types, steps in social network analysis, applications; Advanced methods of measuring perception and beliefs. Multi criteria decision making, analytical hierarchy approach

Block 4: Utilising Research Outputs

Unit 1: Publishing Research

Scholarly communication process; Research reports – Meaning, types, contents; Presentations – Meaning, types, principles of good presentation - Tell 'Em" and KISS 'Em" principles; Research publications – meaning,

importance, types; Guidelines for preparing research papers - Peer review process, citation styles; Open access publishing; Publishing in social media. Software in academic writing

Unit 2: Ethics in Extension Research

Ethics in conducting behavioural research; Human subject research – Meaning, history, and ethical guidelines; Ethical aspects of collecting and using Indigenous knowledge and farmers technologies; Ethical practices in publishing; Plagiarism – meaning, sources, Identifying and correcting plagiarism in a research paper using anti-plagiarism software

Practicals

• Practice in developing research instruments

• Methods of assessing measurement properties of research instruments - dimensionality, reliability and validity

• Hands-on exercise in minimising errors and biases • Hands-on experience in constructing tests, scale and indexes

• Practice in summated scale development using confirmatory factor analysis

• Hands on experience in assessing measurement invariance

• Practicing and collecting data using participatory tools and techniques, analyzing and interpreting qualitative data

• Hands-on experience in writing systematic review using meta-analysis

• Field practice in conducting action research

• Practical experience in writing research paper

• Hands on exercises using software for qualitative data analysis

• Practice in detecting and correcting plagiarism using software

Teaching methods/activities

– Lecture – Assignment (Reading/Writing) – Student presentation – Group Work – Guest Lectures – Research Report (Writing) I

Learning outcome

– The scholars should develop critical skills in conducting systematic and objective research by using robust methods while minimising biases and errors – The students should intelligently choose and apply advanced methods and tools at every stage of research and execute them in a objective way by managing the actors and processes effectively – The students should develop expertise in designing tests, scales and indexes along with other tools to measure the socio-psychological processes at individual, group and community levels

Suggested Reading

Berg B. 2009. Qualitative Research. Methods for the Social Sciences. Boston: Allyn& Bacon. Creswell JW .2007. Qualitative inquiry and research design: Choosing among five approaches (2nd ed.). Thousand Oaks, CA: SAGE Pub. Edwards AL. 1957. Techniques of attitude scale construction. East Norwalk, CT, US: AppletonCentury-Crofts. Furr, RM. 2011. Scale construction and psychometrics for social and personality psychology. Los Angeles: SAGE Pub. Malhotra, NK. 2010. Marketing research: An applied orientation. Sixth Edition. Upper Saddle River, NJ: Prentice Hall Pub. Netemeyer RG, Bearden WO and Sharma S. 2003. Scaling procedures: issues and applications. Thousand Oaks: SAGE Publications. Nunnally, JC, and Bernstein IH. 1994. Psychometric theory (3rd ed.). New York, NY: McGrawHill Rao, C.R. and Sinharay S. 2007. Handbook of Statistics, Vol. 26: Psychometrics, The Netherlands; Elsevier Science B.V. Raykov T and Marcoulides GA. 2010. Introduction to Psychometric Theory. New York, NY: Taylor & Francis Scott J and Carrington PJ. 2011. The SAGE handbook of social network analysis. London: SAGE. Sekaran U and Bougie R. 2013. Research Methods for Business A Skill-Building Approach. 6th Edition, Wiley, New York. Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. Good Practices in Agricultural extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia. Centre for research on innovation and science and policy (CRISP), Hyderabad. India. http://www.aesanetwork.org/ wp-content/uploads/2018/07/6.pdf

Course Title : Technology Commercialisationand Incubation

Course Code : EXT 603

Credit Hours : 2+1

Why this course?

The technology commercialisation and incubation is an emerging area which links technology development, transfer and commercialisation processes with entrepreneurship development. Technology commercialisation aims to realize the value of agricultural technologies developed at the research establishments, by maximising their utility to stakeholders. With the increasing awareness of protecting and commercialising the Intellectual Property Resources (IPR) in the free market economy, there is a need to understand the organic relationship between protection and commercialisation IPR, and entrepreneurship development.

Aim of the course

This course is aimed to develop a critical understanding among extension students about how the technology commercialisation process is linked to IPR management and entrepreneurship development.

The course is organized as follows:

No Blocks	**Units**
1. Technology commercialisation and Commercialisation the modern context	1. Basics of Technology 2. Nature of Agricultural Technology 3. Basics of Technology Transfer and Commercialisation
2. Intellectual Property Resources (IPR) Management	1. Overview of Intellectual Property Resources 2. Systems for protecting IP 3. Management of IPR 4. Protection and Management of Biological Resources 5. Protection, Management and Commercialisation of Grass root and

	Farmers Innovations, Traditional and Indigenous Knowledge 6. Geographical Indications (GI) and Appellation of Origin 7. Genetically Modified Organisms (GMO), Agriculture and Biosafety
3. Technology commercialisation	1. Technology Assessment and Refinement 2. Technology Valuation 3. Technology Commercialisation Strategies 4. Scaling up of Technologies 5. Technology Licensing 6. Technology Takers and Entrepreneurship 7. Policy Support for Technology Commercialisation and Entrepreneurship Development
4. Technology Incubation	1. Basics of Technology Incubation 2. Technology Incubation in India
5. Technology promotion and essential skills for technology commercialisation	1. Technology Promotion 2. Dealing with Entrepreneurs, Agripreneurscommercialisation and Other Stakeholders
6. Emerging approaches in technology commercialisation and incubation	1. Technology Scouting

Theory

Block 1: Technology Commercialisation and the Modern Context

Unit 1: Basics of technology commercialisation

Technology - Definition, functions, process of technological advancement – invention, discovery, innovation and technology; types of innovation - Basic research, Breakthrough innovation, Disruptive Innovation and Sustaining Innovation; Technology transfer and commercialisation

Unit 2: Nature of Agricultural Technology

Agricultural technology – meaning, types; technology generation system; technology life cycle

Unit 3: Basics of Technology transfer and commercialisation

Technology transfer Vs Commercialisation; Technology commercialisation process – elements, models, systems and processes; Technology transfer model – research, disclosure, development and commercialisation

Block 2: Intellectual Property Resources (Ipr) Management

Unit 1: Overview of Intellectual Property Resources

Introduction to IPR; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design; Emergence of IPR Regimes and Governance Frameworks - Trade-Related Aspects of Intellectual Property Rights (TRIPS), Convention on Biological Diversity (CBD), Cartagena Protocol, International Union for Protection of New Plant Varieties (UPOV), and BIMSTEC.

Unit 2: Systems for Protecting IP

IPR protection laws and systems – National IPR Policy; and IPR laws; procedures for filing IP protection; Systems of IP protection and management in agricultural universities and research institutions and also by stakeholders

Unit 3: Management of IPR

Mechanisms of IPR Management – Institutional arrangement, IP Management processes – invention disclosure; IP portfolio management; Infringement management

Unit 4: Protection and Management of Biological Resources

Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for registration and transfer of biological resources; Farmers rights; Mechanisms of documenting/ collecting, protecting and commercialising farmers varieties and other biological resources; National Biodiversity Authority, PPVFRA and other agencies involved in management of biological resources in India. Access to Genetic Resources and Sharing of Benefits

Unit 5: Protection, Management and Commercialisation of Grassrootand Farmers Innovations, Traditional and Indigenous Knowledge

Traditional and Indigenous Knowledge, Grassroot and Farmers Innovations – Meaning, forms and importance; Systems of documentation, registration, protection and commercialisation. Documentation of traditional indigenous knowledge - Traditional Knowledge Digital Library (TKDL), Community Biodiversity Registers (CBRs), People's Biodiversity Registers (PBRs), Plant Biodiversity Register, and Honeybee Network.

Unit 6: Geographical Indications (GI) and Appellation of Origin

Geographical indications and appellation of origin – meaning, origin; Geographical Indications of Goods (Registration and Protection) Act (1999); Documentation, registration and commercialisation of GI protected materials and processes.

Unit 7: Genetically Modified Organisms (GMO), Agriculture and Biosafety

The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety; Regulation of GMO in India - Recombinant DNA Advisory Committee (RDAC), Institutional Bio-safety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), State Bio-safety Coordination Committee (SBCC) and District Level Committee (DLC). Laws and Acts for regulation of GMO - Guidelines for Research in Transgenic Plants, 1998; Seed Policy, 2002; Plant Quarantine Order, 2003; Regulation for Import of GM Products Under Foreign Trade Policy, 2006; National Environment Policy, 2006

Block 3: Technology Commercialisation

Unit 1: Technology Assessment and Refinement

Meaning; Importance; Approaches and methods of assessment and refinement of various technologies – stakeholder oriented approaches including participatory technology assessment and refinement; assessment and refinement of traditional and indigenous knowledge and grassroot innovations

Unit 2: Technology Valuation

Returns to investment; IP Valuation-Oxford context, IP Valuation methods - Cost approach; Income approach - Discounted Cash Flow, Risk-Adjusted Net Present Value, Net Present Value with Monte Carlo Simulation and Real Options Theory; Market approach - Industry Standards Method, Rating/Ranking Method, Rules of Thumb Approach and Auction Method; Hybrid approaches; Royalty rate method

Unit 3: Technology Commercialisation Strategies

Meaning- approaches for technology commercialisation – technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation

Unit 4: Scaling up of Technologies

Meaning, types and stages of technology scaling up; mechanisms

Unit 5: Technology Licensing

Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process

Unit 6: Technology Takers and Entrepreneurship

Meaning; types of technology takers; Technology Taking as a Strategy; Types of entrepreneurship – agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms of entrepreneurship

Unit 7: Policy support for Technology Commercialisation and Entrepreneurship

Development Policy support for entrepreneurship development in India - National Policy on Skill Development and Entrepreneurship and other polices;

Government of India Support for Innovation and Entrepreneurship – Startup India, Make in India, Digital India, Atal Innovation Mission and others; Entrepreneurship policy and schemes at different states of India; Organisations promoting entrepreneurship in India

Block 4: Technology Incubation

Unit 1: Basics of Technology Incubation

Meaning, functions and types; stakeholder oriented incubation process – Livelihood incubation, village incubators

Unit 2: Technology Incubation in India

System of technology incubation- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India

Block 5: Technology Promotion And Essential Skills For Technology Commercialisation

Unit 1: Technology Promotion

Technology promotion – meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers fairs, technology shows

Unit 2: Dealing with Entrepreneurs, Agripreneurs and Other Stakeholders

Business communication; Business Etiquette; business networking

Block 6: Emerging Approaches in Technology Commercialisation and Incubation

Unit 1: Technology Scouting

Technology Scouting and Innovations in technology incubation

Practicals

• Understanding the technology commercialisation process – Visit to Technology Commercialisation Unit of ICAR Institute/ Agricultural University • Understanding the IPR protection practices – Visit to Patent Attorney office • Hands-on experience in drafting IPR application – Patent/Copyright/

Trademark • Understanding protection of biological resources including plant varieties – Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection • Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge • Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications • Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods • Hands on experience in technology valuation • Hands on experience in technology licensing process including drafting agreements • Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Business incubator • Hands on experience in planning and organising technology promotion events • Hands on experience in various techniques in business communication and Business etiquette

Teaching methods/activities

– Lecture cum discussion – Cases – Class exercises – Assignment (Reading/Writing) – Student's Book/Publication Review – Group Presentation

Learning outcome

At the end of the course the students are expected to develop competencies in: – Enabling stakeholders to protect and manage their IPR – Managing IPR to maximise their value realisation through commercialisation, and – Providing mentoring and handholding support to agripreneurs, rural entrepreneurs, start-ups, Farmer Organisations and other forms of entrepreneurs through incubation

Suggested Reading

Bandopadhyay D. 2018. Securing Our Natural Wealth: A Policy Agenda for Sustainable Development in India and for Its Neighbouring Countries. Singapore; Springer. Ghosh, S. and Joshi, A. 2017. Handbook for Non-Profit Incubator Managers. New Delhi: Deutsche GesellschaftfürInternationale. Gupta AK. 2016. Grassroots Innovation: Minds on the margin are not marginal minds. Gurgaon: Penguin Books. ICAR.2018. ICAR Guidelines for Intellectual Property Management and Technology Transfer/ Commercialization (Revised in 2018). Indian Council of Agricultural Research, New Delhi. Pandey N and Dharni K. 2014. Intellectual Property

Rights. Delhi. PHI Learning Pvt. Ltd. Sharma G and Kumar H. 2018. Intellectual property rights and informal sector innovations: Exploring grassroots innovations in India. The Journal of World Intellectual Property. 1-17. DOI: https://doi.org/10.1111/jwip.12097. Stevens AJ. 2016. Intellectual property valuation manual for academic institutions (Report No. CDIP/17/INF/4). Geneva: Committee on Development and Intellectual Property (CDIP). WIPO and ITC. 2010. Exchanging Value – Negotiating Technology Licenses, A Training Manual. World Intellectual Property Organization (WIPO).

Course Title : Educational Technology and Instructional Design

Course Code : EXT 604

Credit Hours : 2+1

Why this course?

Technology, digital media and mobile access have drastically changed how people learn. And the field of education is rapidly becoming a dynamic opportunity for interactive instruction. Today's curriculum developers and instruction designers, especially in the extension and RAS ecosystem, need to equip themselves with the continuous developments in both theory and practice of instructional design so as to create satisfying learning experiences. Similarly, knowledge and skilful use of social media and disruptive technologies like internet of things (IOT), augmented reality, artificial intelligence, etc. makes this course essential for extension professionals who are expected to act as harbingers of change.

Aim of the course

The aim is to develop knowledgeable, responsive and effective teachers committed to educating diverse group of learners in a dynamic extension landscape. This course will help the learners to appreciate the role of technology in learning and how it can be integrated into instructional design to create engaging learning experience in both classroom and online learning environment. The course also aims to prepare the students as competent professionals employable in the extension and RAS providers both as specialised researchers as well as designers.

The course is organized as follows:

No Blocks	Units
1. Educational Technology	1. The Landscape of Educational Technology and Instructional Design
	2. Theories of learning
	3. Technology Enabled Learning
2 Instructional Design	1. Theories of Instruction
	2. Creating Instruction
	3. Instructional Strategies
	4. Evaluating Instruction
	5. Trends in Instructional Design

Theory

Block 1: Educational Technology

Unit 1: The Landscape of Educational Technology and Instructional Design Understanding various terms - educational technology, instructional design, instructional systems design, curriculum design, pedagogy, andragogy; Brief overview of the origin and evolution of ET and ID as theory and practice; what is the relevance of ET and ID relevant in extension and rural advisory services? Extensional professionals as instructional designers and architects of the learning experience

Unit 2: Theories of Learning

What is learning? Critical overview of Behaviorism, Cognitivism, Constructivism and Complex learning theories; instructional designers and learning theories; Types of learning or learning domains- Bloom's taxonomy of the cognitive domain, Krathwohl and Bloom's affective domain and Simpson's psychomotor domain

Unit 3: Technology Enabled Learning

What is the role of technology in education? Digital media, new tools and technology; Open and distance Learning (ODL); Online Education - Synchronous and Asynchronous learning models; eLearning, Massive Open Online Courses - SWAYAM, Open Education Resources (OERs), Course

CERA, EduEx, CoL, RLOs; digital education and its applications in higher agricultural education; Smart classrooms and Campuses, Web-based remote laboratory (WBRL); Integrating media and digital tools into ID; types and implications of disruptive technologies for higher education and extension; Augmented learning; Adaptive learning; meaning, features and good practices in using open source Learning Management Systems (Moodle); Quality assurance and certification in e-learning.

Block 2: Instructional Design

Unit 1: Theories and Models of Instruction

Howard Gardner's Theory of Multiple Intelligences, David Kolb's Experiential Learning Cycle, Albert Bandura's Social Learning Theory, Rand Spiro's Cognitive Flexibility Theory and Its Application In eLearning, Wlodkowski's Motivational Framework for Culturally Responsive Adult Learning; ADDIE Model, Dick and Carey Model, SAM Model, Bloom's Taxonomy; integrating the theories of instruction into the practice of ID in extension and RAS ecosystem.

Unit 2: Creating Instruction

Overview of planning, designing and implementing the curricula and learning experiences; Needs Analysis - meaning, approaches and steps; Task and content analysis - meaning, approaches, steps and techniques (topic analysis, procedural analysis, and the critical incident method); Learner analysis – meaning, importance and approaches, relevance of Maslow's Hierarchy of Needs and learning styles, Captive Audience vs. Willing Volunteers, Universal vs. user-centered design, Learner Analysis Procedures; Writing learning objectives: Meaning of Learning Goal and Learning Objectives; ABCDs of well-stated objectives; Setting goals, translating goals into objectives; Contextualising ADDIE process within the Extension learning environment

Unit 3: Instructional Strategies

Organizing content and learning activities - scope and sequence of instruction; Posner's levels of organizing (Macro, Micro, Vertical, and Horizontal) and structures of organizing (content vs. media) instruction, Gagne's events of instruction, Edgar Dale's Cone of Experience; Methods of Delivery- classroom teaching, programmed instruction, synchronous and asynchronous modes of

distance education; Changing role of a teacher in classroom and teaching competencies.

Unit 4: Evaluating Instruction

Meaning of Assessment, Measurement and Evaluation; Developing learner evaluations and their reliability & validity; assessment techniques for measuring change in knowledge, skill and attitude of learners - Objective Test Items, Constructed-Response Tests, Direct Testing, Performance Ratings, Observations and Anecdotal Records, Rubrics, Portfolios, Surveys and Questionnaires, SelfReporting Inventories, Interviews; Conducting learner evaluation pre-, during and post-instruction; Formative and Summative Evaluation- meaning, approaches and steps; Evaluating Learner Achievement and the Instructional Design Process; Evaluating the success of instruction; Performance appraisal of teachers

Unit 5: Trends in Instructional Design

Alternatives to ADDIE model - Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art; Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries; University assessment and rating methods, returns from agricultural higher education; research in education and instructional design.

Practicals

• Exercises on preparation of the Analysis Report that includes the task/content analysis and learner analysis and the Design Plan includes learning objectives and corresponding instructional strategies and assessment items • Prepare course outline and lesson plan with an appreciation for diverse learning styles based on temperament, gender, and cultural/ethnic differences and deliver a lecture for UG/PG students • Assessing learning styles through Barsch and Kolb inventories • Development and testing of survey instruments for evaluating learning outcomes/ competencies of students • Development and testing of survey instruments for performance appraisal / competency assessment of teachers. • Design an online e-learning module on a topic of interest as a capstone project - integrate and apply the knowledge and skills gained from the course for creating an effective learning experience for a target

audience • Designing and developing a theme based knowledge portals • Exercises on designing an online course using open source LMS like moodle or EdX • Select and evaluate or design for social al media • Prepare a short research paper on recent theories and models of instructional design • Interview an instructional designer of your choice and prepare a synthesis report about what job roles he/she perform, What ID processes does he or she use, challenges faced • Develop a prototype for one of the lessons in your design plan using PowerPoint or a website builder such as Weebly to create the screens integrating multimedia content and various functionalities • Field visit to a virtual learning / augmented learning labs, e-learning labs, distance learning centres, etc. • Hands-on practice with video-editing software, web conferencing and video conferencing solutions

Teaching methods/activities

– Lectures & Videos – Individual and group assignments – Group discussion and debating – Enactive learning exercises – Case studies / Case analysis – Storyboarding – Guest Lectures – Field Visits – Capstone Project – Prototype development .

Learning outcome

After successful completion of this course, the students are expected to be able to: – Develop a critical understanding of concepts of learning and education within the context of agricultural development – Relate and apply learning theories and models to the development, design and evaluation of courses utilizing educational technology and instructional design – Hone their skills to take up research work in analysing and evaluating different Social Sciences: Agricultural Extension Education 301 learning systems, teaching-learning environments, competencies and learning outcomes – Find placement opportunities in the industry for job profiles such as e-learning specialist, training officer, curriculum developer, instructional designer, education consultant, etc.

Suggested Reading

Agarwal JC. 2007. Essentials of Educational Technology Innovations in Teaching – Learning. 2nd Ed. Vikas Publ. House. Allen M. 2013. Leaving ADDIE for SAM: An Agile Model for Developing the Best Learning

GENETICS & PLANT BREEDING

Course Title : Advances in Plant Breeding Systems*

Course Code : GPB 601

Credit Hours : 3(3+0)

Why this course?

This course is an advancement of principles, various plant breeding methodologies and procedures in the development of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker-based utilization of exotic Germplasm and introgression libraries.

Aim of the course

To impart theoretical knowledge about advances in plant breeding.

Theory

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods

in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.

Unit VI

Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

Unit VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

Teaching methods

• Power point presentation • Chalk and Board • Smart board • Lectures • Assignments, quiz • Group tasks, student's presentations

Learning outcome

After completion of this course the student will be able to know variousplant breeding methodologies, principles and procedures for the formation of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker based utilization of exotic Germplasm and Breeding for climate change

Suggested Reading

Agarwal RL. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH. Allard RW. 1966. Principles of Plant Breeding. John Wiley & Sons. Briggs FN and Knowles PF. 1967. Introduction to Plant Breeding. Reinhold. Fehr WR. 1987. Principles of Cultivar Development: Theory and Technique. Vol I. Macmillan. Hayes HK, Immer FR and Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill. Kang MS and Priyadarshan PM (Edit.). 2007. Breeding Major Food Staples. Blackwell Publishing. Kole C. 2013. Genomics and Breeding for Climate-Resilient Crops. Springer. Volume 2-Target Traits. Mandal AK, Ganguli PK and Banerji SP. 1995. Advances in Plant Breeding. Vol. I, II. CBS. Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin. Sharma JR. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill. Simmonds NW. 1979. Principles of Crop Improvement. Longman. Singh BD. 1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani Publishers, New Delhi. Singh P.

1996. Essentials of Plant Breeding. Kalyani Publishers, New Delhi. Welsh JR. 1981. Fundamentals of Plant Genetic and Breeding. John Wiley.

Course Title : Advances in Biometrical Genetics

Course Code : GPB 602

Credit Hours : 3(2+1)

Why this course?

This course is essential to understand various qualitative, quantitative systems/ techniques related to genetic improvement of crops, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection (MAS).

Aim of the course

To impart theoretical knowledge and computation methods for non-allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

Unit I

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F2, FD and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis-Specification, weighted and un-weighted joint scaling test; Effect of linkage to generation mean, specification of mean to G × E interaction.

Unit III

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

Unit IV

G × E Interaction, stability and adaptability; Advanced models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

Unit V

Construction of saturated linkage maps, concept of framework map development; QTLs-different types of markers and mapping populations, linkage maps, mappingStrategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Practical

• Generation mean analysis: ABC scaling test and Joint scaling test- Analysis and interpretation; • Estimation of variance of different filial generations and interpretations; • Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis; • NC Designs: Triple test cross analysis; • Stability analysis: Eberhart and Russel model; • AMMI model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative

model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes; • Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; • Phenotype and Marker linkage studies; • Use of advanced software in biometrical analysis.

Teaching methods

• Power point presentation • Chalk and Board • Smart board • Lectures • Assignments, quiz • Group tasks, student's presentations

Learning outcome

After the completion of this course student will be able to understand various Qualitative and quantitative techniques, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection, Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Suggested Reading

Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall. Dabholkar AR.1993. Elements of Biometrical Genetics. Concept Publishing Co. New Delhi. Falconer DS and Mackay J. 1996. Introduction to Quantitative Genetics (4 Ed.). ELBS/ Longman, London. Mather K and Jinks JL. 1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London. Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi. Roy D. 2000. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi. Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi. Singh RK and Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani Publishers, New Delhi. Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates. Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

Course Title : Molecular Cytogenetics for Crop Improvement

Course Code : GPB 603

Credit Hours : 2(2+0)

Why this course?

This course is needed to understand organization and structure of genome, karyotyping, Pre-breeding and applications of cytogenetically methods for crop improvement

Aim of the course

This course focuses on applications of cytogenetic techniques for crop improvement.

Theory

Unit I

Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content - C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.

Unit II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments.

Unit III

Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker

methods; Duplication - production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.

Unit IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and nonallelic interactions; Telocentric method of mapping.

Unit V

Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

Unit VI

Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.

Teaching methods

• Power point presentation • Chalk and Board • Smart board • Lectures • Assignments, quiz • Group tasks, student's presentations

Learning Outcome

After the completion of this course the student will be able to understand Organization and structure of genome, karyotyping, Pre-breeding, polyploidy and applications of cytogenetically methods for crop improvement.

Suggested Reading

Clark MS and Wall WJ. 1996. Chromosomes: The Complex Code. Chapman & Hall. 30 June 1996 Conger BV. (Ed.). 1981. Cloning Agricultural Plants via in-vitro Techniques. CRC Press. 31 January 2018 Constabel F and Vasil IK. (Eds.). 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press. Gupta P K. 2006. Cytogenetics. Rastogi Publisher Lal R and Lal S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology. CRC Press. Mantel SH and Smith H. 1983. Plant Biotechnology. Cambridge University Press. Sen SK and Giles KL. (Eds.). 1983. Plant Cell Culture in Crop Improvement. Plenum Press. 13 July 2013 Yao-Shan F. 2002. Molecular Cytogenetics: Protocols and Application. Human Press

Course Title : Plant Genetic Resources, Conservation and Utilization

Course Code : GPB 604

Credit Hours : 2(2+0)

Why this course?

This course is needed to make the student aware about the importance of Plant Genetic Resources its Conservation and Utilization in crop improvement.

Aim of the course

To impart knowledge on the methods of germplasm conservation and its utilization

Theory

Unit I

Concept of natural reserves and natural gene banks; In situ conservation of wild species in nature reserves: in situ conservation components, factors influencing conservation value, national plan for in situ conservation; in situ conservation of agro-biodiversity on-farm; scientific basis of in situ conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of in situ conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

Unit II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

Unit III

In-vitro storage, maintenance of in-vitro culture under different conditions, in-vitro bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of in-vitro gene bank.

Unit IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrant-cryoprotectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Unit V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

Teaching methods

• Power point presentation • Chalk and Board • Smart board • Lectures • Assignments, quiz • Group tasks, student's presentations.

Learning outcome

After the completion of this course the student will be able to know about the various techniques of conservation of Plant Genetic Resources and its Utilization in crop improvement.

Suggested Reading

Ellis RH, Roberts EH and White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO/ IBPGR Pl. Genet. Resources News 41-3-18. Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge. Paroda RS and Arora RK.1991. Plant Genetic resource Conservation and management, NBPGR, New-Delhi. Simmonds NW. 1979. Principles of Crop Improvement, Longman. Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository. Processed Report. USDA-ARS and Oregon State Univ. Oregon, USA. Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

Course Title : Genomics in Plant Breeding*

Course Code : GPB 605

Credit Hours : 3(3+0)

Why this course?

The knowledge of recent trends in plant genomics, genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics is essential in rapid crop improvement programmes.

Aim of the course

To impart practical skills in advanced molecular techniques in genome mapping structural/ functional genomics.

Theory

Unit I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Unit III

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

Unit IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

Unit V

Development and management of database; Applications of bioinformatics tools/ software in genomics for crop improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics.

Unit VI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

Teaching methods

• Power point presentation • Chalk and Board

• Smart board • Lectures • Assignments, quiz • Group tasks, student's presentations

Learning outcome

After the completion ofthis course, the student will have expertise on about different techniques for genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics in crop improvement

Suggested Reading

Alonso JM, Stepanova AN. 2015. Plant Functional Genomics: Methods and Protocols. Springer. Chopra VL, Sharma RP, Bhat SR and Prasanna BM. 2007. Search for New Genes. Academic Foundation, New Delhi. Hackett PB, Fuchs

JA and Messing JW. 1988. An Introduction to Recombinant DNA Technology— Basic Experiments in Gene and Manipulation. 2nd Ed. Benjamin Publication Co. Primose SB and Twyman RM. 2006. Principles of Gene Manipulation and Genomics. 7th Ed. Wiley-Blackwell Publishing. Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Laboratory Press. Singh BD. 2005. Biotechnology: Expanding Horizons. Kalyani Publishers, New Delhi. Somers DJ, Langridge P, Gustafson JP. 2009. Plant Genomics: Methods and Protocols. Springer.

e-Resources

http://gramene.org https://www.arabidopsis.org https://wheat.pw.usda.gov http://ncbi.nlm.nih.gov http://www.maizegenetics.net

Course Title : IPR and Regulatory Mechanism (e-course)*

Course Code : GPB 609

Credit Hours : 1(1+0)

Why this course?

Biodiversity conservation and its judicious utilization are important in sustainable plant breeding programs. Breeders' and farmers' rights are important in scenario of globalization of agriculture so knowledge of IPRs is essential for a plant breeder to protect his varieties.

Aim of the course

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR), related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledgebased economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

Teaching methods

• Power point presentation • Smart board • Assignments, quiz • Group tasks, student's presentations

Learning outcome

The students will have acquaintance of intellectual property rights, national and international laws on biodiversity and sustainable use of plant genetic resources through transfer and sharing. Can assist in follow up of various treatises and laws for research collaborations at international levels.

Suggested Reading

Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

DEPARTMENT OF PLANT PATHOLOGY

Course Title : Advances in Mycology

Course Code : PL PATH 601

Credit Hours : 2+1

Aim of the course

To acquaint with the advances in mycology

Theory

Unit I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfection.

Unit II

Population biology, pathogenic variability/ vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Unit III

Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

Unit IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

Practical

• Isolation, purification and identification of cultures, spores and mating type determination; • Study of conidiogenesis-Phialides, porospores, arthospores; • Study of fruiting bodies in Ascomycotina; • Identification of fungi up to species level; • Study of hyphal anastomosis; • Morphology of representative plant pathogenic genera form different groups of fungi; • Molecular characterization of fungi.

Suggested Reading

Alexopoulos CJ, Mims CW and Blackwell M. 1996. Introductory Mycology. John Wiley & Sons, New York. Dube HC. 2005. An Introduction to Fungi. 3rd Ed. Vikas Publ. House, New Delhi. Kirk PM, Cannon PF, David JC and Stalpers JA. (Eds.). 2001. Ainsworth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington. Maheshwari R. 2016. Fungi: Experimental Methods in Biology 2nd edn. CRC Press, US. Ulloa M and Hanlin RT. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Minnesota. Webster J and Weber R. 2007. Introduction to Fungi. Cambridge University Press, Cambridge.

Course Title : Advances in Plant Virology

Course Code : PL PATH 602

Credit Hours : 2+1

Aim of the course

To educate about the advanced techniques and new developments in plant virology.

Theory

Unit I

Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudorecombination, component re-assortment, etc.

Unit II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Unit III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent

in situ hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and noncoding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

Unit IV

Gene expression, regulation and viral promoters.Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

Practical

• Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation; • Acquaintance with different serological techniques (i) DAC-ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation,and autoradiography; • PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny); • Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

Suggested Reading

Davies 1997. Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida. Fauquet et al. 2005. Virus Taxonomy. VIII Report of ICTV. Academic Press, New York. Gibbs A and Harrison B. 1976. Plant Virology – The Principles. Edward Arnold, London. Jones P, Jones PG and Sutton JM. 1997. Plant Molecular Biology: Essential Techniques. John Wiley & Sons, New York. Khan J A and Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Howarth Press, New York. Maramorosch K, Murphy FA and Shatkin AJ. 1996. Advances in Virus Research. Vol. 46. Academic Press, New York. Pirone TP and Shaw JG. 1990. Viral Genes and Plant Pathogenesis. Springer Verlag, New York. Roger Hull. 2002. Mathew's Plant Virology (4th

Ed.). Academic Press, New York. Thresh JM. 2006. Advances in Virus Research. Academic Press, New York.

Course Title : Advances in Plant Pathogenic Prokaryotes

Course Code : PL PATH 603

Credit Hours : 2+1

Aim of the course

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

Theory

Unit I

Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof-Parmas (EMP) pathway, Phosphoketolase Pathway and EntnerDoudoroff Pathway).

Unit II

Current trends in taxonomy and identification of phytopathogenicprokarya: International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Unit III

Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

Unit IV

Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of

bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

Practical

• Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/ pathovar specific primers; • Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts; • Important and emerging diseases and their management strategies.

Suggested Reading

Dale JW and Simon P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York. Garrity GM, Krieg NR and Brenner DJ. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York. Gnanamanickam SS. 2006. Plant-Associated Bacteria. Springer Verlag, New York. Mount MS and Lacy GH. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, New York. Sigee DC. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge. Starr MP. 1992. The Prokaryotes. Vols. I–IV. Springer Verlag, New York.

Course Title : Molecular Basis of Host-pathogen Interaction
Course Code : PL PATH 604
Credit Hours : 3 (2+1)
Aim of the course

To understand the concepts of molecular biology and biotechnology in relation to host plant- pathogen interactions.

Theory

Unit I

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles

to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

Unit II

Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Unit III

Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of genefor-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

Unit IV

Pathogen population genetics and durability, viruses vs cellular pathogens.Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

• Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation; • Gene mapping and marker assisted selection; • Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

Suggested Reading

Chet I. 1993. Biotechnology in Plant Disease Control. John Wiley & Sons, New York. Gurr SJ, McPohersen MJ and Bowlos DJ. (Eds.). 1992. Molecular Plant Pathology – A Practical Approach. Vols. I & II, Oxford Univ. Press,

Oxford. Mathew JD. 2003. Molecular Plant Pathology. Bios Scientific Publ., UK. Ronald PC. 2007. Plant-Pathogen Interactions: Methods in Molecular Biology. Humana Press, New Jersey. Stacey G and Keen TN. (Eds.). 1996. Plant Microbe Interactions. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

Course Title : Principles and Procedures of Certification
Course Code : PL PATH 605
Credit Hours : 1 (1+0)
Aim of the course
To acquaint with the certification procedures of seed and planting material.
Theory
Unit I
Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.
Unit II
Methods used in certification of seeds, vegetative propagules and in-vitro cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.
Reference
Association of Official Seed Certifying Agencies. Hutchins D and Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, UK. ISHI-veg Manual of Seed Health Testing Methods. ISHI-F Manual of Seed Health Testing Methods. ISTA Seed Health Testing Methods. Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. US National Seed Health System.
e-Resources

http://www.aosca.org/index.htm.
http://www.worldseed.org/enus/international_seed/ishi_vegetable.html
http://www.worldseed.org/en-us/international _seed/ ishi_f.html
http://www.seedtest.org/en/content—1—1132—241.html
http://www.seedhealth.org

Course Title : Plant Biosecurity and Biosafety
Course Code : PATH 606
Credit Hours : 2 (2+0)
Aim of the course
To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.
Theory
Unit I
History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.
Unit II
National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.
Unit III
Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/ resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.
Suggested Reading
Biosecurity: A Comprehensive Action Plan. Biosecurity Australia. Biosecurity for Agriculture and Food Production. FAO Biosecurity Toolkit 2008. Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance. Khetarpal RK

SOIL SCIENCE

Course Title : Recent Trends in Soil Physics

Course Code : Soil 601

Credit Hours : 2+0

Aim of the course
To provide knowledge of modern concept sin soil physics.

Theory

Unit I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC).

Unit II
Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated waterflow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional waterflow.

Unit III

Theories of horizontal and vertical infiltration under different boundary conditions.

Unit IV

Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Unit V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heatflow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.

Unit VII

Solar and terrestrial radiation measurement, dissipation and distribution in soilcrop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infrared thermometer.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Reading

• Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
• Hanks and Ascheroft. 1980. Applied Soil Physics. Springer Verlag.
• Hillel D. 1980. Applications of Soil Physics. Academic Press.
• Hillel D. 1980. Environmental Soil Physics. Academic Press.
• Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
• Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley Interscience.
• Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
• Oswal MC. 1994. Soil Physics. Oxford & IBH.

Course Title : Modern Concept in Soil Fertility

Course Code : Soil 602

Credit Hours : 2+0

Aim of the course

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

Unit I

Nutrient availability-concept and relationships, modern concepts of nutrient s availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

Unit III

Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Unit V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit VII

Carbon– a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Reading

• Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley & Sons.
• Barker V Allen and Pilbeam David J. 2007. Handbook of Plant Nutrition. CRC / Taylor & Francis.
• Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Educ.
• Cooke GW. 1979. The Control of Soil Fertility. Crossby Lockwood & Sons.
• Epstein E. 1987. Mineral Nutrition of Plants - Principles and Perspectives. International Potash Institute, Switzerland.
• Kabata- Pendias Alina 2001. Trace Elements in Soils and Plants. CRC / Taylor & Francis.
• Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
• Mortvedt JJ, Shuman LM, Cox FR and Welch RM. (Eds.). 1991. Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.
• Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
• Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
• Stevenson FJ. (Ed.). 1982. Nitrogen in Agricultural Soils. Soil Science Society of America, Madison.
• Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1990. Soil Fertility and Fertilizers. 5th Ed. Macmillan Publ.
• Wild A. (Ed.). 1988. Russell's Soil Conditions and Plant Growth. 11th Ed. Longman.

Course Title : Physical Chemistry of Soil

Course Code : Soil 603

Credit Hours : 2+0

Aim of the course

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

Unit I

Colloidal chemistry of in organic and organic components of soils–their formation, clay organic interaction.

Unit II

Predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit III

Thermodynamics of nutrient transformations in soils; Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Unit IV

Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit V

Common solubility equilibria-carbonates, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil chemical behaviour on research for solving field problems.

Suggested Reading

• Bear RE. 1964. Chemistry of the Soil. Oxford & IBH.
• Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.

• Fried M and Broeshart H. 1967. Soil Plant System in Relation to Inorganic Nutrition. Academic Press.
• Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
• Greenland DJ and Hayes MHB. 1978. Chemistry of Soil Constituents. John Wiley & Sons.
• Jurinak JJ. 1978. Chemistry of Aquatic Systems. Department of Soil Science and Biometeorology, Utah State University
• McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.
• Sparks DL. 1999. Soil Physical Chemistry. 2nd Ed. CRC Press.
• Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
• Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.
• Sposito G. 1989. The Chemistry of Soils. Oxford University Press.
• Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley.
• vanOlphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Course Title : Soil Genesis and Micromorphology

Course Code : Soil 604

Credit Hours : 2+0

Aim of the course

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

Unit I

Pedogenic evolution of soils; soil composition and characterization.

Unit II

Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Unit III

Assessment of soil profile development by mineralogical and chemical analysis.

Unit IV

Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil micro pedology and soil taxonomy on research for solving field problems.

Suggested Reading

• Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu. • Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ. • Dixon JB and Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison. • Grim RE. 1968. Clay Mineralogy. McGraw Hill. • Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi. • Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi • Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani. • USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington. • Wade FA and Mattox RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH.

Course Title : Biochemistry of Soil Organic Matter

Course Code : Soil 605

Credit Hours : 2+0

Aim of the course

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

Unit I

Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit III

Nutrient transformation–N, P, S; tracemetal interaction with humic substances, significance of chelation reactions in soils.

Unit IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clayorganic matter complexes.

Unit V

Humus-pesticide interactions in soil, mechanisms.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil biochemistry on research for solving field problems.

Reading Materials

• Lynch JM, Willey JM. Soil Biotechnology. • Paul EA and Clark FE. Soil Microbiology and Biochemistry • Sherwood LM and Woolverton CJ. Prescott's Microbiology. • Subba Rao NS. Advances In Agricultural Microbiology

Course Title : Soil Resource Management

Course Code : Soil 606

Credit Hours : 3+0

Aim of the course

To impart the students basic holistic knowledge on soil resource and latest developments in its sustainable use.

Unit I

Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes,

genereserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

Unit II

Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

Unit III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

Unit IV

Soil conservation planning; land capability classification; soil conservation in special problem are as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

Unit V

Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

Unit VI

Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil resources on research for solving field problems.

VII. Suggested Reading

• Abrol IP and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR, New Delhi. • Andriesse JP. 1988. Nature and Management of Tropical Peat Soils, Soil Resources, FAO Soils Bulletin 59, Management and Conservation Service, Land and Water Development Division, FAO, Rome • Blackwell, Dent D and Young A. 1981. Soil Survey and Land Evaluation. George Allen and Unwin, London. • Burrough A and McDonnell RK. 1998.Principles of Geographical Information System. Oxford University Press. • Dan Binkley D and Fisher R. 2012. Ecology and Management of Forest Soils,4th Edition, Wiley. • FAO. 1996. Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development. FAO Land and Water Bulletin.5. FAO, Rome. • Faroq M and Siddique K. (Ed.). 2015. Conservation Agriculture, Springer Nature, Chennai, India. • FESL. 1993. An International Framework for Evaluating Sustainable Land Management, FAO World Soil Resources Report No. 73, Land Development Division, FAO, Rome. • ISSS. 1994. Management of Land and Water Resources for Sustainable Agriculture and Environment. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi. • Lal R, Blum WEH, Valentine C and Stewart BA. (Editors). 1988. Methods for Assessment of Soil Degradation. CRC Press, Boca Raton. • Mulders MA. 1987. Remote Sensing in Soil Science. Elsevier Science Publishers, Amsterdam. • Sehgal J. 2014. A Text Book of Pedology Concepts and Application. Kalyani publishers, New Delhi. • SSSA 1996. Methods for Assessing Soil Quality. SSSA Publication Number 49, Madison, Wisconsin, USA.

Note: For minor courses please refer the concerned department's courses outline.

HORTICULTURE (FRUIT SCIENCE)

Course Title : Innovative Approaches in Fruit Breeding

Course Code : FSC 601

Credit Hours : (3+0)

Why this course ?

Modern day fruit culture witnesses rapid changes in production technologies and market trends.Ever changing environment and consumer preferences warrant constant development and adoption of genetically improved varieties.There is more thrust on novelty and distinctness in view of ever increasing competition with enhanced emphasis on tailor made and trait specific designer varieties and rootstocks. The course is thus designed to integrate updated information on inherent breeding systems and innovative gene manipulation technologies enhancing breeding efficiency.

Aim of the course

To update knowledge on current trends and innovative approaches in fruit breeding. The structural organisation of the course is as under:-

No. Blocks	Units
1 Introduction	Current Trends and Status
2 Genetic Mechanisms	Inheritance Patterns and Breeding Systems
3 Breeding for Specific Traits	Plant Architecture, Stress Tolerance and Fruit Quality
4 Fast-Track Breeding	Transgenics, Markers and Genomics

Theory

Block 1: Introduction

Unit I: Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc.

Block 2: Genetic Mechanisms

Unit I: Inheritance Patterns and Breeding Systems:

Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.

Block 3: Breeding for Specific Traits

Unit I: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits; use of apomixis, gene introgression and wide hybridization (alien genes).

Block 4: Fast-Track Breeding

Unit I: Transgenics, Markers and Genomics:

Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding – marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing tehnologies.

Crops

Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops .

Teaching Methods/ Activities

• Class room Lectures • Student Seminars/ Presentations • Field Tours/ Demonstrations • Assignments

Learning outcome

On successful completion of the course, the students are expected to • Develop updated knowledge on current breeding objectives and trends • Equip with information on innovative approaches enhancing breeding efficiency

Suggested Reading

Al-Khayari J, Jain SN and Johnson DV. 2018. Advances in Plant Breeding Strategies. Vol. 3: Fruits. Springer. Badenes S and Byrne DH. 2012. Fruit Breeding. Springer. Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer. Kole C and Abbott AG. 2012. Genetics, Genomics and Breeding of Stone fruits. CRC. Kole, C. 2011. Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits. Springer-Verlag. Kole C. 2011. Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits. Springer -Verlag. Jain SN and Priyadarshan PM. 2009. Breeding Plantation and Tree Crops: Tropical Species; Temperate Species. Springer -Verlag. Janick J and Moore JN, 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons, USA. Orton T. 2019. Methods in Fruit Breeding. Elsevier. Singh SK, Patel VB, Goswami AK, Prakash J and Kumar C. 2019. Breeding of Perennial Horticultural Crops. Biotech Books. Delhi.

Course Title : Modern Trends in Fruit Production

Course Code : FSC 602

Credit Hours : (3+0)

Why this course ?

Recent technological developments in propagation and cultural practices paves the way to grow fruit crops in an intensive and mechanised mode. As such a course has been developed to provide latest knowledge and updated account of modern production systems enhancing overall productivity.

Aim of the course

To keep abreast with latest developments and trends in production technologies of tropical, subtropical and temperate fruits.

The course structure is as follows:-

No. Blocks	Units
1 Introduction	General Concepts and Current Scenario
2 Advanced Technologies	Propagation, Planting Systems and Crop Regulation
3 Management Practices	Overcoming Stress and Integrated Approaches

Theory

Block 1: Introduction

Unit I: General Concepts and Current Scenario:

National and International scenario, national problems.

Block 2: Advanced Technologies

Unit I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation.

Block 3: Management Practices

Unit I: Overcoming Stress and Integrated Approaches:

Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM) – Current topics.

Crops

Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit.

Teaching Methods/ Activities

• Class room Lectures • Student Seminars/ Presentations • Field Tours/ Demonstrations • Assignments VIII. Learning outcome After the successful completion of the course, the students would have • Updated knowledge on current trends in fruit production.

Suggested Reading

Bartholomew DP, Paull RE and Rohrbach KG. eds. 2002. The Pineapple: Botany, Production, and Uses. CAB International. Bose TK, Mitra SK and Sanyol D. Eds. 2002. Fruits of India – Tropical and Sub- Tropical. 3rd Ed. Vols. I, II. NayaUdyog, Kolkata, India. Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi. Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi. Gowen S. 1995. Bananas and Plantains. Chapman & Hall Publication, US. Litz RE. ed. 2009. The Mango: Botany, Production and Uses. CAB International. Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi. Robinson JC and Saúco VG. 2010. Bananas and Plantains (Vol. 19). CAB International. Samson JA. 1980. Tropical Fruits. Longman, USA. Sharma RR and Krishna H. 2014. Fruit Production: Major Fruits. Daya Publishing House, Delhi. Singh S, Shivankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. Jagmander Book Agency, New Delhi. Stover RH and Simmonds NW. 1991. Bananas.

Longman, USA. Chadha KL, Ahmed N, Singh SK and Kalia P. 2016. Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality.Daya Publishing House, New Delhi. Childers NF, Morris JR and Sibbett GS. 1995. Modern Fruit Science: Orchard and Small Fruit Culture. Horticultural Publications, USA. Erez A. 2013. Temperate Fruit Crops in Warm Climates. Springer Science. Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. Temperate and Subtropical Fruit Production. CAB International. Ryugo K. 1998. Fruit Culture: Its Science and Art. John Wiley & Sons, USA. Tromp J, Webster AS and Wertheim SJ. 2005. Fundamentals of Temperate Zone Tree Fruit Production. Backhuys Publishers, Lieden, The Netherlands. Westwood MN. 2009. Temperate Zone Pomology: Physiology and Culture. 3rdEdn. Timber Press, USA.

Course Title : Recent Developments in Growth Regulation

Course Code : FSC 603

Credit Hours : (3+0)

Why this course ?

Technological advancements have resulted in deeper understanding of growth and developmental processes in plants. There is equal and just need to apply these in fruit crops for harnessing maximum benefits in term of yield and quality. So a course has been designed to provide latest information on physiological and biochemical aspects of growth and development.

Aim of the course

To develop updates on recent advances in growth regulation of fruit crops. Structure of the course is as under:

No. Blocks	**Units**
1 Introduction	Current Concepts and Principles

2 Growth Substances	Phytohormones and Growth Regulators
3 Growth and Development	Regulation of Developmental Processes

Theory

Block 1: Introduction

Unit I: Current Concepts and Principles:

Eco-physiological influences on growth and development of fruit crops-flowering, fruit set- Crop load and assimilate partitioning and distribution.

Block 2: Growth Substances

Unit I: Phytohormones and Growth Regulators:

Root and canopy regulation, study of plant growth regulators in fruit culture-structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

Block 3: Growth and Development

Unit I: Regulation of Developmental Processes:

Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production. Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

Teaching Methods/ Activities

• Class room Lectures • Student Seminars/ Presentations • Field Tours/ Demonstrations • Assignments

Learning outcome

After the successful completion of the course, the students would have • Complete understanding of growth dynamics in various fruit crops • Know-how on manipulation of growth and development processes.

Suggested Reading

Bhatnagar P. 2017. Physiology of Growth and Development of Horticultural Crops. Agrobios (India). Buchanan B, Gruiessam W and Jones R. 2002. Biochemistry and Molecular Biology of Plants. John Wiley & Sons, US. Fosket DE. 1994. Plant Growth and Development: A Molecular Approach. Academic Press, USA. Leopold AC and Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, US. Richard N. Arteca. 1995. Plant Growth Substances – Principles and Applications. Chapman & Hall, USA. Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Plants (I. Ridge, Ed.), Oxford University Press. Salisbury FB and Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publication.

Course Title : Abiotic Stress Management in Fruit Crops

Course Code : FSC 606

Credit Hours : (2+1)

Why this course ?

Low soil fertility coupled with unpredictable and unfavourable environments often result in stress conditions. Non-availability of optimum level of inputs and congenial weather necessitates the development of suitable management practices to overcome various abiotic stresses. Hence a course is customized.

Aim of the course

To updates knowledge on recent trends in management of abiotic stresses in fruit crops. The course is organised as follows:

No. Blocks	Units
1 Introduction	Basic Aspects and Principles
2 Stress Impact	Assessment, Physiology and Performance
3 Stress Management	Mitigation Measures and Conservation Practices

Theory

Block 1: Introduction

Unit I: Basic Aspects and Principles:

Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.). Pollution – increased level of CO2, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

Block 2: Stress Impact

Unit I: Assessment, Physiology and Performance:

Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.

Block 3: Stress Management

Unit I: Mitigation Measures and Conservation Practices:

Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting,

increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

Practical

• Seed treatment/ hardening practices (2); • Container seedling production (2); • Analysis of soil moisture estimates (FC, ASM, PWP) (1); • Analysis of plant stress factors, RWC, chlorophyll flourosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate, etc. under varied stress situations (5); • Biological efficiencies, WUE, solar energy conversion and efficiency (2); • Crop growth sustainability indices and economics of stress management (2); • Visit to orchards and watershed locations (2);

Teaching Methods/ Activities

• Class room Lectures • Laboratory/ Field Practicals • Student Seminars/ Presentations • Field Tours/ Demonstrations • Assignments

Learning outcome

On successful completion of the course, the students are expected to generate know-how on • Various types of abiotic stresses and their effects • Physiological processes underlying abiotic stresses • Management and conservation practices to overcome stress

Suggested Reading

Blumm A. 1988. Plant Breeding for Stress Environments. CRC Publication, USA. Christiansen, MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International Science, USA. Kanayama Y and Kochetor. 2015. Abiotic Stress Biology in Horticultural Plants. Springer. Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.

HORTICULTURE (VEGETABLE SCIENCE)

Course Title : Recent Trends in Vegetable Production

Course Code : VSC 601

Credit Hours : (3+0)

Why this course ?

India is the second largest producer of vegetables in the world, next only to China. Most challenging task is to ensure for continuous and enough supply of vegetables to growing population. Urban areas are experiencing substantial increase in population; this growth is accompanied with change in food habits and rising concerns for food quality. Here, food quality refers to the optimum levels of the nutrition in the food along with the minimized amount of the chemical (pesticides/ fertilizers) residues used in the production of the vegetables. Vegetables are being highly seasonal, perishable are also capital and labour intensive and need care in handling and transportation. Environmental stress (climate change) and shortage of water and land resources are major constraints haunting the production. Though the advances in science and information technology has resulted in more comfortable world with global linkages, these advances has led to changes in production practices. Thus, the students of vegetable science need to have an understanding of recent trends in production technology of vegetable crops and their management.

Aim of the course

To keep abreast with latest developments and trends in production technology of vegetable crops.

The course is constructed given as under:

No. Block	Unit
1 Recent trends in vegetable	1. Solanaceous crops production
	2. Cole crops
	3. Okra, onion, peas and beans, amaranth and drumstick.
	4. Root crops and cucurbits
	5. Tuber crops

Theory

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable

production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of:

Unit I

Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.

Unit II

Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli.

Unit III

Okra, onion, peas and beans, amaranth and drumstick.

Unit IV

Root crops and cucurbits: Carrot, beet root, turnip and radish and cucurbits

Unit V

Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

Teaching Methods/ Activities

• Classroom Lectures • Assignment (written and speaking) • Student presentation • Group discussion V

Learning outcome

After successful completion of this course, the students are exposed to: • Acquire the knowledge about recent trends in production technology of vegetable crops

Suggested Reading

Bose TK and Som NG. 1986. Vegetable crops of India. Nayaprokash. Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. NayaUdyog. Brewster JL. 1994. Onions and other vegetable alliums. CABI. Chadha KL and Kalloo G (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra Publ. House. Chadha KL (Ed.). 2002. Hand book of horticulture. ICAR. Chauhan DVS (Ed.). 1986. Vegetable production in India. Ram prasad and Sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani. FFTC. Improved vegetable production in Asia. Book Series No. 36. Ghosh SP, Ramanujam T, Jos JS, Moorthy SN and Nair RG. 1988. Tuber crops. Oxford and IBH. Gopalakrishanan TR. 2007. Vegetable crops. New India Publ. Agency. Hazra P and Som MG. 2015. Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana. Hazra P. 2016. Vegetable science. 2ndedn, Kalyani publishers, Ludhiana. Hazra P. 2019. Vegetable production and technology. New India publishing agency, New Delhi. Kallo G and Singh K. (Ed.). 2001. Emerging scenario in vegetable research and development. Research periodicals and Book Publ. House. Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S and Pallai SV. 1996. Tropical tuber crops, problems, prospects and future strategies. Oxford and IBH. Rana MK. 2008. Olericulture in India. Kalyani Publishers, New Delhi. Rana MK. 2008. Scientific cultivation of vegetables. Kalyani Publishers, New Delhi. Rubatzky VE and Yamaguchi M. (Eds.). 1997. World vegetables: principles, production and nutritive values. Chapman and Hall. Saini GS. 2001. A Text Book of oleri and flori culture. Aman Publishing House. Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel Dekker. Shanmugavelu KG. 1989. Production technology of vegetable crops. Oxford and IBH. Sin MT and Onwueme IC. 1978. The tropical tuber crops. John Wiley and Sons. Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co. Singh NP, Bhardwaj AK, Kumar A and Singh KM. 2004. Modern technology on Vegetable production. International book distr. Co. Singh PK, Dasgupta SK and Tripathi SK. 2006. Hybrid vegetable development. International book distr. Co. Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. Comm. Res. Centre. Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Course Title : Advances in Breeding of Vegetable Crops

Course Code : VSC 602

Credit Hours : (3 +0)

Why this course ?

The improvement of vegetable crops has until recently, been largely confined to conventional breeding approaches and such programmes rely on hybridization of plants which have desirable heritable characteristics and on naturally or artificially induced random mutations. The introduction of new genetic information can result in increased resistance to insect pest, diseases tolerance to environmental condition, improved quality, etc. The modern biotechnological tools like molecular assisted selection, double haploidy, genetic engineering, etc. can be of immense importance for rapid development of superior varieties with desirable qualitative and quantitative traits. Therefore, conventional breeding in conjunction with molecular biology has bright prospects of developing high yielding vegetable varieties with high nutraceuticals and bio active compounds suitable for fresh as well as processed market. The students of vegetable science who are having breeding as major subject need to have an understanding of recent technologies in vegetable crops.

Aim of the course

To impart knowledge on the recent research trends and advances in breeding of vegetable crops. The course is constructed given as under:

No.	Block	Unit
1	Advances in Breeding of vegetable crops	I. Solanaceous crops and okra
		II. Cucurbits and Cole crops
		III. Legumes and leafy vegetables
		IV. Root crops and onion
		V. Tuber crops

Theory

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, biofortification, in-vitro breeding, marker assisted breeding, haploidy, development of transgenic.

Unit I

Solanaceous crops—Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato

Unit II
Cucurbits and Cole crops

Unit III
Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.
Unit IV
Root crops and onion—Carrot, Beetroot, Radish, Turnip, Onion
Unit V
Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea
Teaching Methods/ Activities
• Classroom Lectures • Assignment (written and speaking) • Student presentation • Group discussion
Learning outcome
After successful completion of this course, the students are exposed to: • Breeding objectives and trends • Recent Adavnces in vegetable breeding
Suggested Reading
Allard RW. 1999. Principle of plant breeding. John Willey and Sons, USA. Basset MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ. Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House. Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable crops: Breeding and seed production. Vol. I. Kalyani. Gardner EJ. 1975. Principles of genetics. John Wiley and Sons. Hayes HK, Immer FR and Smith DC. 1955. Methods of plant breeding. McGraw-Hill. Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. Plant Breeding-principles and prospects. Chapman and Hall. Hazra P and Som MG. 2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani Publishers, Ludhiana, 459 p Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA. Kalloo G. 1998. Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency. Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro Botanical Publ. Paroda RS and Kalloo G. (Eds.). 1995. Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO. Peter KV and Pradeepkumar T. 2008. Genetics and breeding of vegetables. Revised, ICAR. Peter KV and Hazra P. (Eds). 2012.

Hand book of vegetables. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p. Rai N and Rai M. 2006. Heterosis breeding in vegetable crops. New India Publ. Agency. Ram HH. 1998. Vegetable breeding: principles and practices. Kalyani Publishers, New Delhi. Simmonds NW. 1978. Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi. Singh BD. 1983. Plant breeding. Kalyani Publishers, New Delhi. Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid vegetable development. International Book Distributing Co. Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

Course Title : Abiotic Stress Management in Vegetable Crops

Course Code : VSC 603

Credit Hours : (2+1)

Why this course ?

Improvement of vegetable crops has traditionally focused on enhancing a plant's ability to resist diseases or insects. That is evidenced by the large number of disease- or insect-resistant cultivars or germplasm released and used. Research on crop resistance or tolerance to abiotic stresses (heat, cold, drought, flood, salt, pH, etc.) has not received much attention. However, that is changing as a result of the research and publicity of global warming. The changing environments pose serious and imminent threats to vegetable production and place unprecedented pressures on the sustainability of vegetable production. The challenges and opportunities coexist for our dynamic and resilient industry. In addition to conserving resources, we should mitigate abiotic stresses and adapt to the warming planet. The student of vegetable science need to know the different methods involved to mitigate the abiotic stress in vegetable crops.

Aim of the course

To update knowledge on the recent research trends in the field of abiotic stress management in vegetables. • To teach management practices to mitigate abiotic stress in vegetable crops The course is constructed given as under:

No.	Block	Unit
1	Abiotic stress management in	I Environmental stress vegetable crops II Mechanism and measurements of tolerance III Soil-plant-water relations IV Techniques of vegetable growing qunder high stress condition V Use of chemicals

Theory

Unit I

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

Unit II

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

Unit III

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

Unit IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

Unit V

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

Practical

• Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops; • Measurement of tolerance to various stresses in vegetable crops; • Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions; • Use of chemicals for alleviation of different stresses.

Teaching Methods/ Activities

• Classroom Lectures • Assignment (written and speaking) • Student presentation • Hands on training of different procedure • Group discussion

IX. Learning outcome

After successful completion of this course, the students are expected to: • Acquire the knowledge about effect of different abiotic stresses on vegetables • Methods to mitigate abiotic stress in vegetables

Suggested Reading

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House. Dwivedi P and Dwivedi RS. 2005. Physiology of abiotic stress in plants. Agrobios. Janick JJ. 1986. Horticultural science. 4th Ed. WH Freeman and Co. Kaloo G and Singh K. 2001. Emerging scenario in vegetable research and development. Research periodicals and book publ. house. Kaloo G. 1994.Vegetable breeding. Vols. I-III. Vedams eBooks. Lerner HR. (Eds.). 1999. Plant responses to environmental stresses. Marcel Decker. Maloo SR. 2003. Abiotic stresses and crop productivity.Agrotech Publ. Academy. Narendra T. et al. 2012. Improving crops resistance to abiotic stress. Wiley and Sons.US. Peter KV and Pradeep Kumar T. 2008. Genetics and breeding of vegetables. (Revised Ed.). ICAR. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p. Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p. Ram HH. 2001. Vegetable breeding. Kalyani. Rao NK. (Eds.). 2016. Abiotic stress physiology of horticultural crops. Springer publication.

Course Title : Seed Certification, Processing and Storage of Vegetable Seeds

Course Code : VSC 604

Credit Hours : (2+1)

Why this course ?

Every farmer should able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage. Timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers. The seeds plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Quality seed production which follows efficient

certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures through the Seeds Act, 1966. In the current scenario, the demand for good quality certified seeds far exceed the availability in the market. This manual provides details about production and procurement of good quality seeds.

Aim of the course

To impart the knowledge on seed certification, processing and storage of vegetable seeds

Theory

Unit I

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.

Unit II

Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

Unit III

Principles of seed processing, Methods of seed drying and cleaning, seed processing plant- Layout and design, seed treatment, seed quality enhancement, packaging and marketing.

Unit IV

Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).

Unit V

Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.

Practical

• General procedures of seed certification; • Field inspection and standards; • Isolation and rouging; • Inspection and sampling at harvesting, threshing and processing; • Testing physical purity, germination and moisture, grow-out test;

• Visit to regulatory seed testing and plant quarantine laboratories; • Seed processing plants and commercial seed stores.

Teaching Methods/ Activities

• Classroom Lectures • Assignment (written and speaking) • Student presentation individual or in group • Hands on training of different procedure • Group discussion

Learning outcome

After successful completion of this course, the students are expected to: • Acquire the knowledge on seed certification • Acquire the knowledge on seed processing and storage

Suggested Reading

Agarwaal PK and Anuradha V. 2018. Fundamentals of seed science and technology. Brilliant publications, New Delhi. Basra AS. 2000. Hybrid seed production in vegetables. CRC press, Florida, USA. Bench ALR and Sanchez RA. 2004. Handbook of seed physiology. Food products press, NY/ London. Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi Copland LO and McDonald MB. 2004. Seed science and technology, Kluwer academic press. Fageria MS, Arya PS and Choudhry AK. 2000. Vegetable crops: breeding and seed production Vol 1. Kalyani publishers, New Delhi. George RAT. 1999. Vegetable seed production (2nd Edition). CAB International. Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani publishers, Ludhiana, 459p Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. Seed: A global perspective. Associated publishing company, New Delhi. Singhal NC. 2003. Hybrid seed production. Kalyani publishers, New Delhi.