कार्यालय कुलसचिव,
राजमाता विजयाराजे सिंधिया कृषि विश्वविद्यालय, ग्वालियर (म.प्र.)

राजा पंचम सिंह मार्ग, आकाशवाणी के पास, ग्वालियर (म.प्र) 474002

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क्र. / कु.स. / प्रशा. / 2025–26 / 3264 दिनांक: 29/12/2025

अधिसूचना

विश्वविद्यालय प्रमंडल की 59वीं बैठक दिनांक 10.12.2025 के पद क्रमांक 03 में लिये गये निर्णयानुसार बी.एस.एम.ए. (Broad Subject Matter Area) और भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली की निर्धारित अनुशंसाओं के अनुसार स्नातकोत्तर (पी.जी. एवं पीएच.डी.) डिग्री कार्यक्रमों में संचालित विभिन्न विभागों के पाठ्यक्रमों में संशोधन करने हेतु विश्वविद्यालयीन समिति द्वारा तैयार नवीन संशोधित स्नातकोत्तर (पी.जी. एवं पीएच.डी.) पाठ्यक्रम शैक्षणिक सत्र 2025–26 से लागू करने का अनुमोदन किया गया।

संलग्न– नवीन संशोधित स्नातकोत्तर (पी.जी. एवं पीएच.डी) पाठ्यक्रम
(माननीय कुलपति महोदय द्वारा अनुमोदित)

कुलसचिव
दिनांक: 29/12/2025

पृष्ठा. क्र. / कु.स. / प्रशा. / 2025–26 / 3265
प्रतिलिपि – सूचनार्थ एवं आवश्यक कार्यवाही हेतु–

1. अधिष्ठाता कृषि संकाय, रा.वि.सि.कृ.वि.वि. ग्वालियर।
2. निदेशक अनुसंधान सेवाएं, रा.वि.सि.कृ.वि.वि., ग्वालियर।
3. निदेशक विस्तार सेवाएं, रा.वि.सि.कृ.वि.वि., ग्वालियर।
4. निदेशक शिक्षण एवं उपनिदेशक छात्र कल्याण, रा.वि.सि.कृ.वि.वि., ग्वालियर।
5. लेखानियंत्रक, रा.वि.सि.कृ.वि.वि. ग्वालियर।
6. अधिष्ठाता, कृषि / उद्यानिकी महाविद्यालय, ग्वालियर / इंदौर / सिहोर / खण्डवा / मंदसौर
7. सूचना एवं जनसंपर्क अधिकारी, रा.वि.सिं.कृ.वि.वि., ग्वालियर।
8. उप कुलसचिव (स्था. / शैक्ष.), रा.वि.सिं.कृ.वि.वि., ग्वालियर।
9. सहायक कुलसचिव (विधि), रा.वि.सिं.कृ.वि.वि., ग्वालियर।
10. पोर्टल प्रभारी, रा.वि.सिं.कृ.वि.वि., ग्वालियर की ओर वि.वि. पोर्टल पर अपलोड कराने हेतु।
11. निज सचिव, माननीय कुलपतिजी, रा.वि.सिं.कृ.वि.वि., ग्वालियर।
12. सुरक्षा नस्ती।

कुलसचिव

Course Curriculum of P.G. and Ph.D. Programmes
(2025-26)

Directorate of Instructions & Student Welfare

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
Gwalior [M.P.]

कुल गीत

शस्य श्यामला वसुधा के पूजन-अर्चन में,
वंदनीय मानवता के सुख-संवर्द्धन में,
कृषि विद्या के विश्व पीठ में
मंगल दीप जले।
शत्-शत् सुमन खिले।।

कृषि विज्ञान शोध के नव-नव विस्तारण में,
चंबल माता, मातृ नर्मदा के आँगन में,
कृषि-क्षेत्रों में सतत् सर्वदा
नव प्रकाश फैले।
शत्-शत् सुमन खिले।।

कृषक जनों तक पहुँचे कृषि विज्ञान समीरण,
धन-धान्य पूर्ण हो अपना देश प्रदेश सनातन,
मुस्कायें हीरे मोती-सी
नित नूतन फसलें।
शत्-शत् सुमन खिले।।

वीरांगिनी लक्ष्मीबाई की पुण्य भूमि में,
मातृश्री विजयाराजे की शुभ स्मृति में,
स्थापित मंदिर गढ़े निरन्तर
कीर्तिमान उजले।

शत्-शत् सुमन खिले।।

Course Curriculum of P.G. and Ph.D. Programmes (2025-26)

2025

Directorate of Instructions & Student Welfare
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
Gwalior [M.P.]

Patron	:	**Prof. Arvind Kumar Shukla** Vice Chancellor

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Dr. Arvind Kumar Shukla
Vice-Chancellor

//FOREWORD//

I am pleased to present the revised curriculum for Postgraduate (PG) and Doctoral (Ph.D.) programs, developed through a comprehensive and consultative process involving subject experts from all disciplines. This restructuring aligns with the academic standards of the BSMA and the Indian Council of Agricultural Research (ICAR), while also addressing the specific academic needs of our institution.

The updated framework features unit-wise and lecture-wise teaching plans and integrates relevant minor courses, fully compliant with ICAR guidelines. These enhancements are aimed at strengthening academic rigor, expanding curricular scope, and ensuring the relevance of our programs to current and emerging trends in research, industry, and higher education.

This initiative reflects our institution's commitment to maintaining high academic standards and preparing our students to meet future professional and scholarly challenges with competence and confidence.

The revised curriculum will be implemented from the academic session 2025–26. I sincerely thank all faculty members and experts who contributed to this significant academic advancement.

(Arvind Kumar Shukla)

या देवी सर्वभूतेषु बुद्धि-रूपेण संस्थिता।
नमस्तस्यै नमस्तस्यै नमस्तस्यै नमो नमः।।

CONTENT

Distribution of Semester wise Courses in Different Post Graduate Degree Programme

M.Sc. (Ag.) Agronomy

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
Agron-501	Modern Concepts in Crop Production	3(3+0)
Agron-504	Principles and Practices of Water Management	3(2+1)
Agron-511	Cropping System and Sustainable Agriculture	2(2+0)
Agron-513	Principles and practices of organic farming	3(2+1)
Minor Courses		
Soils- 506	Soil Biology and Biochemistry	3(2+1)
Soils- 513	Soil Survey and Land use Planning	2(2+0)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
Agron-502	Principles and practices of soil fertility and nutrient management	3(2+1)
Agron-503	Principles and Practices of Weed Management	3(2+1)
Agron-505**	Conservation Agriculture	2(1+1)
Agron-512	Dryland Farming and Watershed Management	3(2+1)
Minor Course		
Soil-505	Soil erosion and conservation	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
PSMA-591	Master's Seminar	1(0+1)
PSMA 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
PSMA -599	Master's Research	15(0+15)

M.Sc. (Ag.) Agricultural Economics

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
AEC-501	Micro Economic Theory and Applications	3(3+0)
AEC-502	Agricultural Production Economics	2(1+1)
AEC-503	Agricultural Marketing and Price Analysis	3(2+1)
AEC-504	Macro Economics and Policy	2(2+0)
Minor Courses		
AEC-514	Commodity Future Trading	2(2+0)
EXT-505	Capacity Development	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
AEC-505	Econometrics	3(2+1)
AEC-507	Agricultural Finance and Project Management	3(2+1)
AEC-508	Linear Programming	2(1+1)
AEC-509	Research Methodology for Social Sciences	2(1+1)
Minor Course		
EXT-506	ICTs for Agricultural Extension and Advisory Services	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
AEC-591	Master's Seminar	1(0+1)
AEC- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
AEC -599	Master's Research	15(0+15)

M.Sc. (Ag.) Agricultural Extension Education

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
EXT-501	Extension Landscape	2(2+0)
EXT-502	Applied Behaviour Change	3(2+1)
EXT-505	Capacity Development	3(2+1)
Minor Courses		
EXT-508	Managing Extension Organisations	3(2+1)
AEC-503	Agricultural Marketing and Price Analysis	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
EXT-503	Organisational Behaviour and Development	3(2+1)
EXT-504	Research Methodology in Extension	3(2+1)
EXT-506	ICTs for Agricultural Extension and Advisory Services	3(2+1)
EXT-507	Evaluation and Impact Assessment	3(2+1)
Minor Course		
EXT-510	Gender Mainstreaming	3(2+1)
Supporting Course		
STAT-512	Basic Sampling Techniques	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
EXT-591	Master's Seminar	1(0+1)
EXT- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IVth Semester

Course Code	Course Title	Credit Hours
EXT-599	Master's Research	15(0+15)

M.Sc. (Ag.) Entomology

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
ENT-501	Insect Morphology	3(2+1)
ENT-503	Insect Taxonomy	3(1+2)
ENT-508	Concepts of Integrated Pest Management	2(2+0)
ENT-515	Techniques in Plant Protection	1(0+1)
Minor Courses		
PP-505	Principles of Plant Pathology	3(2+1)
PP-506	Techniques in Detection and Diagnosis of Plant Diseases	2(0+2)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
ENT-502	Insect Anatomy and Physiology	3(2+1)
ENT-505	Biological Control of Insect Pests and Weeds	3(2+1)
ENT-506	Toxicology of Insecticides	3(2+1)
ENT-509	Pests of Field Crops	3(2+1)
Minor Course		
PP-515	Diseases of Field and Medicinal Crops	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
ENT-591	Master's Seminar	1(0+1)
ENT- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
ENT -599	Master's Research	15(0+15)

M.Sc. (Ag.) Genetics and Plant Breeding

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
GPB-501	Principles of Genetics	3(2+1)
GPB-502	Principles of Plant Breeding	3(2+1)
GPB-516	Breeding for Stress Resistance and Climate Change	3(2+1)
GPB-504	Varietal Development and Maintenance Breeding	2(1+1)
Minor Course		
PL PATH-505	Principles of Plant Pathology	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
GPB-503	Fundamentals of Quantitative Genetics	3(2+1)
GPB-510	Seed Production and Certification	2(1+1)
GPB-506	Molecular Breeding and Bioinformatics	3(2+1)
GPB-508	Mutagenesis and Mutation Breeding	3(2+1)
Minor Courses		
PL PATH-515	Diseases of Field and Medicinal Crops	3(2+1)
ENT-509	Pests of Field Crops	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
GPB-591	Master's Seminar	1(0+1)
GPB- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
GPB -599	Master's Research	15(0+15)

M.Sc. (Ag.) Molecular Biology and Biotechnology

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
MBB-501	Principles of Biotechnology	3(3+0)
MBB-502	Fundamentals of Molecular Biology*	3(3+0)
MBB-504	Techniques in Molecular Biology I*	3(0+3)
MBB-509	Plant Tissue culture	3(2+1)
Minor Courses		
GPB-501	Principles of Genetics	3(2+1)
GPB-502	Principles of Plant Breeding	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
MBB-503	Molecular Cell Biology*	3(3+0)
MBB-505	Omics and Systems Biology*	3(2+1)
MBB-514	Nano Biotechnology	3(2+1)
Minor Courses		
GPB-504	Varietal Development and Maintenance Breeding	2(1+1)
GPB-506	Molecular Breeding and Bioinformatics	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
MBB -591	Master's Seminar	1(0+1)
MBB - 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
MBB -599	Master's Research	15(0+15)

M.Sc. (Ag.) Plant Pathology

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
PL Path-501	Mycology	3(2+1)
PL Path-503	Plant pathogenic prokaryotes	3(2+1)
PL Path-505	Principles of Plant Pathology	3(2+1)
PL Path-506	Techniques in Detection and Diagnosis of Plant Diseases	2(0+2)
Minor Course		
ENT-508	Concepts of Integrated Pest Management	2(2+0)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
PL Path-502	Plant Virology	3(2+1)
PL Path-504	Plant Nematology	3(2+1)
PL Path-515	Diseases of Field and Medicinal Crops	3(2+1)
Minor Courses		
ENT-506	Toxicology of Insecticides	3(2+1)
ENT-509	Pests of Field Crops	3(2+1)
Supporting Course		
STAT-511	Experimental Design	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
PL Path -591	Master's Seminar	1(0+1)
PL Path - 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
PL Path -599	Master's Research	15(0+15)

*** Note: Out of two courses one course will be registered as per availability of the course teacher.**

M.Sc. (Ag.) Soil Science

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
Soil-503	Soil Chemistry	3(2+1)
Soil-504	Soil Minerology, genesis and classification	3(2+1)
Soil-506	Soil Biology and Biochemistry	3(2+1)
Soil-513	Soil Survey and Land Use Planning	3(2+1)
Minor Course		
AGRON-513	Principles and Practices of Organic Farming	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
Soil-501	Soil Physics	3(2+1)
Soil-502	Soil Fertility and Fertilizer Use	3(2+1)
Soil-505	Soil Erosion and Conservation	3(2+1)
Minor Courses		
AGRON-512	Dryland Farming and Watershed management	3(2+1)
AGRON-505	Conservation Agriculture	2(2+0)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
FSC-591	Master's Seminar	1(0+1)
FSC- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
FSC -599	Master's Research	15(0+15)

M.Sc. (Ag.) Horticulture (Floriculture and Landscaping)

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
FLS-501	Systematics of Ornamental Plants	3(2+1)
FLS-503	Commercial Production of Cut Flowers	3(2+1)
FLS-505	Ornamental Gardening and Landscaping	3(2+1)
Minor Courses		
PL PATH-505	Principles of Plant Pathology	3(2+1)
PSMA-509	Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
FLS-502	Breeding of Ornamental Plants	3(2+1)
FLS-504	Commercial Production of Loose Flowers	3(2+1)
FLS-507	Nursery Management in Ornamental Plants	3(2+1)
FLS-509	Value Addition in Floriculture	3(2+1)
Minor Course		
FSC-506	Canopy Management in Fruit Crops	2(1+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
FLS -591	Master's Seminar	1(0+1)
FLS 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
FLS -599	Master's Research	15(0+15)

M.Sc. (Ag.) Horticulture (Fruit Science)

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
FSC-501	Tropical Fruit Production	3(2+1)
FSC-502	Sub-Tropical and Temperate Fruit Production	3(2+1)
FSC-513	Minor Fruit Production	3(2+1)
Minor Course		
PL Path-505	Principles of Plant Pathology	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
FSC-503	Propagation and Nursery Management of Fruit Crops	3(2+1)
FSC-504	Breeding of Fruit Crops	3(2+1)
FSC-506	Canopy Management in Fruit Crops	2(1+1)
FSC-507	Growth and Development of Fruit Crops	3(2+1)
Minor Courses		
Soil-502	Soil fertility and fertilizer use	3(2+1)
ENT-506	Toxicology of Insecticides	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
FSC-591	Master's Seminar	1(0+1)
FSC- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
FSC -599	Master's Research	15(0+15)

*** Note: Out of two courses one course will be registered as per availability of the course teacher.**

M.Sc. (Ag.) Horticulture (Plantation, Spices, Medicinal and Aromatic Crops)

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
PSMA-501	Production of Plantation Crops	3(2+1)
PSMA-502	Production of Spice Crops	3(2+1)
PSMA-503	Production of Medicinal and Aromatic Crops	3(2+1)
PSMA-509	Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops	3(2+1)
Minor Course		
PL PATH 505	Principles of Plant Pathology	3(2+1)
Supporting Course		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
PSMA -504	Breeding of Plantation and Spice Crops	3(2+1)
PSMA -505	Breeding of Medicinal and Aromatic Crops	2(1+1)
PSMA -511	Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops	3(2+1)
Minor Courses		
FSC-506	Canopy Management in Fruit Crops	2(1+1)
FLS-509	Value Addition in Floriculture	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
PSMA-591	Master's Seminar	1(0+1)
PSMA 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
PSMA -599	Master's Research	15(0+15)

M.Sc. (Ag.) Horticulture (Vegetable Science)

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
VSC-501	Production of Cool Season Vegetable Crops	3(2+1)
VSC-504	Principles of Vegetable Breeding	3(2+1)
VSC-509	Production of Underutilized Vegetable Crops	3(2+1)
Minor Course		
PL PATH-505	Principles of Plant Pathology	3(2+1)
Supporting Cours		
STAT-502	Statistical Methods for Applied Sciences	4(3+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
VSC-502	Production of Warm Season Vegetable Crops	3(2+1)
VSC-503	Growth & Development of Vegetable Crops	3(2+1)
VSC-507	Protected Cultivation of Vegetable Crops	2(1+1)
VSC-514	Post Harvest Management of Vegetable Crops	3(2+1)
Minor Courses		
Soil-502	Soil fertility and fertilizer use	3(2+1)
ENT-506	Toxicology of Insecticides	3(2+1)
Supporting Course		
STAT-511	Experimental Designs	3(2+1)
Common Course		
PGS-504	Basic Concepts in Laboratory Techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
FSC-591	Master's Seminar	1(0+1)
FSC- 599	Master's Research	15(0+15)
Common Courses		
PGS-502	Technical Writing and Communication Skills	1(0+1)
PGS-503	Intellectual Property and its management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
FSC -599	Master's Research	15(0+15)

Distribution of Semester wise Courses in Different Post Graduate Degree Programme

Ph.D. Agronomy

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
Agron-603	Irrigation management	3(2+1)
Agron-604	Recent trends in weed management	2(2+0)
Agron-608	Research and Publication ethics	2(2+0)
Minor Courses		
Soil-602	Modern concept in soil fertility	2(2+0)
Soil-605	Bio-chemistry of soil organic matter	2(2+0)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
Agron-601	Current trends in Agronomy	3(3+0)
Agron-602	Recent trends in crop growth and productivity	3(2+1)
Minor Course		
Soil-606	Soil resource management	3(3+0)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
Agron -691	Doctoral Seminar	1(0+1)
Agron -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
Agron -692	Doctoral Seminar	1(0+1)
Agron 699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
Agron -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
Agron -699	Doctoral Research	20 (0+20)

Ph.D. Agricultural Economics

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
AEC-601	Advanced Micro Economic Analysis	2(1+1)
AEC-603	Advanced Econometrics	3(2+1)
Minor Courses		
AEC-606	Advanced Agricultural Marketing and Price Analysis	3(2+1)
EXT-602	Methodologies for Social and Behavioural Sciences	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
AEC-602	Advanced Macro Economic Analysis	2(2+0)
AEC-604	Advanced Production Economics	3(2+1)
Minor Course		
EXT-603	Technology Commercialization and Incubation	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
AEC -691	Doctoral Seminar	1(0+1)
AEC -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
AEC -692	Doctoral Seminar	1(0+1)
AEC 699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
AEC -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
AEC -699	Doctoral Research	20 (0+20)

Ph.D. Agricultural Extension Education

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
EXT-601	Policy Engagement and Extension	3(2+1)
EXT-602	Methodologies for Social and Behavioural Sciences	3(2+1)
Minor Course		
AEC-606	Advanced Agricultural Marketing and Price Analysis	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
EXT-603	Technology Commercialization and Incubation	3(2+1)
EXT-604	Educational Technology and Instructional Design	3(2+1)
Minor Course		
EXT-607	Facilitation for People centric Development	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
EXT -691	Doctoral Seminar	1(0+1)
EXT -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
EXT -692	Doctoral Seminar	1(0+1)
EXT 699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
EXT -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
EXT -699	Doctoral Research	20 (0+20)

Ph.D. Entomology

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
ENT-601	Insect Phylogeny and Systematics	3(1+2)
ENT-603	Insect Ecology and Diversity	3(2+1)
ENT-605	Bio-inputs for Pest Management	3(2+1)
Minor Courses		
PP-605	Principles and Procedures of Certification	1(1+0)
PP-606	Plant Biosecurity and Biosafety	2(2+0)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
ENT-602	Insect Physiology and Nutrition	3(2+1)
ENT-606	Insect Toxicology and Residues	3(2+1)
ENT-607	Plant Resistance to Insects	2(1+1)
Minor Course		
PP-604	Molecular Basis	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
ENT-691	Doctoral Seminar	1(0+1)
ENT -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
ENT -692	Doctoral Seminar	1(0+1)
ENT 699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
ENT -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
ENT -699	Doctoral Research	20 (0+20)

Ph.D. Genetics and Plant Breeding

I Semester

Course Code	Course Title	Credit Hours
Major Courses		
GPB-601	Advances in Plant Breeding Systems	3(3+0)
GPB-603	Molecular Cytogenetics for Crop Improvement	2(2+0)
GPB-604	Plant Genetics Resources, Conservation and Utilization	2(2+0)
Minor Course		
MBB-504	Techniques in Molecular Biology -I	3(0+3)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course Code	Course Title	Credit Hours
Major Courses		
GPB-602	Advances in Biometrical Genetics	3(2+1)
GPB-605	Genomics in Plant Breeding	3(3+0)
GPB-609	IPR and Regulatory Mechanism (e-course)	1(1+0)
Minor Course		
PP-604	Molecular Basis of Host-pathogen Interaction	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
GPB-691	Doctoral Seminar	1(0+1)
GPB-699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
GPB-692	Doctoral Seminar	1(0+1)
GPB-699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
GPB-699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
GPB-699	Doctoral Research	20 (0+20)

Ph.D. Plant Pathology

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
PL PATH-601	Advances in Mycology	3(2+1)
PL PATH-605	Principles and Procedures of Certification	1(1+0)
PL PATH-606	Plant Biosecurity and Biosafety	2(2+0)
Minor Course		
ENT-605	Bio-inputs for Pest Management	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
PL PATH-602	Advances in Virology	3(2+1)
PL PATH-603	Advances in Plant Pathogenic Prokaryotes	3(2+1)
PL PATH-604	Molecular Basis of Host-pathogen Interaction	3(2+1)
Minor Course		
ENT-606	Insect Toxicology and Residues	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Packages	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
PL PATH- 691	Doctoral Seminar	1(0+1)
PL PATH -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
PL PATH -692	Doctoral Seminar	1(0+1)
PL PATH- 699	Doctoral Research	18(0+18)
	Total	19

V Semester

Course Code	Course Title	Credit Hours
PL PATH-699	Doctoral Research	20(0+20)

VI Semester

Course Code	Course Title	Credit Hours
Soil 699	Doctoral Research	20(0+20)

Ph.D. Soil Science

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
Soil-602	Modern concept in soil fertility	2(2+0)
Soil-603	Physical Chemistry of soil	2(2+0)
Soil-605	Bio-chemistry of Soil organic matter	2(2+0)
Minor Course		
Agron-603	Irrigation Management	3(2+1)
Supporting Course		
STAT-521	Applied regression analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
Soil-601	Recent trends in soil physics	2(2+0)
Soil-604	Soil Genesis and micromorphology	2(2+0)
Soil-606	Soil resource management	3(3+0)
Minor Course		
Agron-602	Recents trends in crop growth and productivity	3(2+1)
Supporting Course		
STAT-522	Data analysis using statistical packages	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
Soil 691	Doctoral Seminar	1(0+1)
Soil 699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
Soil 692	Doctoral Seminar II	1(0+1)
Soil 699	Doctoral Research	18(0+18)
	Total	19

V Semester

Course Code	Course Title	Credit Hours
Soil 699	Doctoral Research	0+20

VIth Semester

Course Code	Course Title	Credit Hours
Soil 699	Doctoral Research	0+20

Ph.D. Fruit Science

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
FSC-601	Innovative Approaches in Fruit Breeding	3(3+0)
FSC-602*	Modern Trends in Fruit Production	3(3+0)
Minor Course		
ENT-605	Bio-inputs for Pest Management	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
FSC-603*	Recent Developments in Growth Regulation	3(3+0)
FSC-606	Abiotic Stress Management in Fruit Crops	3(2+1)
Minor Course		
VSC-604	Seed Certification, processing and storage of vegetable seeds	3(2+1)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
FSC -691	Doctoral Seminar	1(0+1)
FSC -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
FSC -692	Doctoral Seminar	1(0+1)
FSC -699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
FSC -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
FSC -699	Doctoral Research	20 (0+20)

Ph.D. Vegetable Science

I Semester

Course No.	Course Title	Credit Hours
Major Courses		
VSC-601*	Recent trends in Vegetable Production	3(3+0)
VSC-602	Advances in Breeding of Vegetable Crops	3(3+0)
Minor Course		
ENT-605	Bio-inputs for Pest Management	3(2+1)
Supporting Course		
STAT-521	Applied Regression Analysis	3(2+1)
Common Course		
PGS-501	Library and Information Services	1(0+1)

II Semester

Course No.	Course Title	Credit Hours
Major Courses		
VSC-603	Abiotic Stress Management in Vegetable Crops	3(2+1)
VSC-604*	Seed Certification, Processing and Storage of Vegetable Seeds	3(2+1)
Minor Course		
FSC-603*	Recent Developments in Growth Regulation	3(3+0)
Supporting Course		
STAT-522	Data Analysis Using Statistical Package	3(2+1)
Common Course		
PGS-504	Basic concepts in laboratory techniques	1(0+1)

III Semester

Course Code	Course Title	Credit Hours
VSC -691	Doctoral Seminar	1(0+1)
VSC -699	Doctoral Research	17(0+17)
Common Courses		
PGS-502	Technical writing and communications skills	1(0+1)
PGS-503	Intellectual property and its Management in Agriculture	1(1+0)
PGS-505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)

IV Semester

Course Code	Course Title	Credit Hours
VSC -692	Doctoral Seminar	1(0+1)
VSC 699	Doctoral Research	18 (0+18)

V Semester

Course Code	Course Title	Credit Hours
VSC -699	Doctoral Research	20 (0+20)

VI Semester

Course Code	Course Title	Credit Hours
VSC -699	Doctoral Research	20 (0+20)

Syllabus of Courses Offered for PG Program in Different Departments

Agronomy

Modern Concept in Crop Production **Agron-501**

Credit Hrs.: **3(3+0)**

Theory:

S. No.	Topics	No. of lectures
	UNIT-I	
1.	**Crop growth analysis**	2
2.	**Crop growth analysis in relation to environment**	1
3.	**Growth curves**	1
4.	**Seed production techniques in various crops**	1
5.	**Agro-climatic zones of India**	1
6.	**Agro-ecological zones of India**	1
7.	**Quantitative agro-biological principles**	2
8.	**Inverse yield nitrogen law;**	1
9.	**Mitscherlich yield equation, its interpretation and applicability**	1
10.	**Baule unit**	1
11.	**Effect of lodging in cereals;**	1
12.	**Management strategies to reduce lodging**	1
13.	**Physiology of grain yield in cereals;**	1
14.	**Optimization of plant population and planting geometry in relation to different resources,**	2
	UNIT-II	
15.	**Concept of ideal plant type**	1
16.	**Crop modelling for desired crop yield**	1
17.	**Scientific principles of crop production;**	1
18.	**Crop response production functions;**	2
19.	Concept of soil plant relations; yield and environmental stress	2
20.	Use of growth hormones and regulators for better adaptation in stressed condition.	1
21.	Integrated farming systems,	1
22.	organic farming,	1
23.	Resource conservation technology	1
24.	Modern concept of tillage;	1
	UNIT-III	
25.	Dry farming;	2
26.	Determining the nutrient needs for yield potentiality of crop plants,	1
27.	Concept of balance nutrition and integrated nutrient management;	2
28.	Precision agriculture	1
29.	Modern crop production concepts: soil less cultivation, aeroponic, hydroponic,	2
30.	Robotic and terrace farming.	1

31.	Use of GIS, GPS and remote sensing in modern agriculture,	2
32.	Precision farming	1
33.	Protected agriculture.	1
	Total	**42**

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.

Principles and Practices of Soil Fertility & Nutrient Management Agron-502

Credit Hrs.: **3(2+1)**

Theory:

S. No.	Topics	No. of Lectures
	UNIT I	
1.	**Soil fertility and productivity**	1
2.	**Factors affecting Soil fertility and productivity**	1
3.	**Features of good soil management**	1
4.	**Problems of supply and availability of nutrients**	1
5.	**Relation between nutrient supply and crop growth;**	1
6.	**Organic farming - basic concepts and definitions.**	1
7.	**Criteria of essentiality of nutrients**	1
8.	**Essential plant nutrients – their functions, nutrient deficiency symptoms**	1
9.	**Transformation and dynamics of major plant nutrients**	1
10.	**Preparation and use of farmyard manure**	1
11.	**Compost: Types, methods and factors affecting composting process**	1

	UNIT II	
12.	**Green manures, status & its application effect on crop growth**	1
13.	**Vermicompost: composition, factors affecting its quality & its application effect on crop growth**	1
14.	**biofertilizers and other organic concentrates their composition,**	1
15.	**availability and crop responses;**	1
16.	**Recycling of organic wastes and residue management**	1
17.	Soil Less Cultivation	1
18.	Commercial fertilizers; composition, relative fertilizer value and cost;	1
19.	Crop response to nutrients & their application	1
20.	Residual effects and fertilizer use efficiency; agronomic, chemical and physiological	2
21.	Methods of increasing fertilizer use efficiency;	1
	UNIT III	
22.	Nutrient interactions	1
23.	Fertilizer mixtures and grades;	1
24.	Time and methods of manures and fertilizers application;	1
25.	foliar application and its concept;	1
26.	Relative performance of organic and inorganic nutrients;	1
27.	economics of fertilizer use;	1
28.	integrated nutrient management;	1
29.	Use of vermicompost and residue wastes in crops	1
	Total	**30**

Practicals

Sl. No.	Description
1.	Determination of soil pH and soil EC
2.	Determination of soil organic C
3.	Determination of available N, P, K and S of soil
4.	Determination of total N, P, K and S of soil
5.	Determination of total N, P, K, S in plant
6.	Computation of optimum and economic yield

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

Principles and Practices of Weed Management **Agron-503**

Credit: 3(**2+1**)

Theory:

S. No.	Topics	No. of lectures
	UNIT-I	
1.	**Weed biology, and Ecology and Classification**	2
2.	**Crop-weed competition including allelopathy**	1
3.	**Principles and methods of weed control and classification management**	2
4.	**Weed indices**	1
5.	**Weed shift in different eco-systems**	1
6.	**Herbicides introduction and history of their development;**	1
7.	**Classification of herbicide based on chemical, physiological application and selectivity**	3
8.	**Mode and mechanism of action of herbicides**	1
9.	**Herbicide structure - activity relationship**	1
10.	**Factors affecting the efficiency of herbicides**	1
	UNIT-II	
11.	**Herbicide formulations**	1
12.	**Herbicide mixtures, sequential application of herbicides & Herbicide rotation**	1
13.	**Weed control through use of nano-herbicides**	1
14.	**Bio-herbicides, myco-herbicides and bio-agents**	1
15.	Allelochemicals	1
16.	Movement of herbicides in soil and plant	1
17.	Degradation of herbicides in soil and plants	1
18.	Herbicide resistance	1
19.	Herbicide residue, persistence and management;	1
20.	Development of herbicide resistance in weeds and crops and their management	1
	UNIT-III	
21.	Herbicide combination and rotation	1
22.	Weed management in major crops and cropping systems;	1
23.	Alien, invasive and parasitic weeds and their management;	1
24.	Weed shifts in cropping systems;	1
25.	Aquatic and perennial weed control and weed control in non-crop area	1
26.	Integrated weed management;	1
27.	Recent development in weed management- robotics, use of drones and aeroplanes, organic etc.,	1

28.	Cost: benefit analysis of weed management	1
	Total	**32**

Practicals

Sl. No.	Description
1.	Identification of important weeds of different crops
2.	Preparation of a weed herbarium
3.	Weed survey in crops and cropping systems
4.	Weed indices calculation and interpretation with data
5.	Preparation of spray solutions of herbicides for high and low-volume sprayers
6.	Use of various types of spray pumps and nozzles and calculation of swath width
7.	Crop-weed competition studies
8.	Bioassay of herbicide resistance residues
9.	Calculation of herbicide requirement
10.	Economics calculation of weed control
11.	Herbicide resistance analysis in plant and soil

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.*

Principles and Practices of Water Management — Agron-504

Credit : 3(**2+1**)

Theory:

S. No.	Topics	No. of lectures
	UNIT-I	
1.	**Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state**	2

2.	**Major irrigation projects; extent of area and crops irrigated in India and in different states**	1
3.	**Field water cycle and water movement in soil & plants**	1
4.	**Soil-water- plant relationships; transpiration; water absorption by plants.**	2
5.	**Plant response to water stress, Crop plant adaptation to moisture stress condition.**	2
6.	**Water availability and its relationship with nutrient availability and loses. Soil, plant and meteorological factors determining water needs of crops**	2
7.	**Scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation**	2
	UNIT-II	
8.	**Management of water in controlled environments and polyhouses; Automated irrigation system**	2
9.	**Irrigation efficiency and water use efficiency**	2
10.	Water management of crop and cropping system	3
11.	Quality of irrigation water and management of saline water for irrigation	1
12.	Estimation of ET and effective rainfall	2
13.	Excess of soil water and plant growth; water management in problematic soils	2
	UNIT-III	
14.	Drainage requirement of crops and methods of field drainage, their layout and spacing	2
15.	Rain water management and its utilization for crop production.	2
16.	Soil moisture conservation technique	1
17.	Water harvesting and its techniques for enhancing water productivity	2
18.	Hydroponics and Its tools	1
19.	Water management of crops under climate change scenario	2
	Total	**34**

Practicals

Sl. No.	Description
1.	Determination of Field capacity by field method
2.	Determination of Permanent Wilting Point by sunflower pot culture technique
3.	Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
4.	Determination of Hygroscopic Coefficient
5.	Determination of maximum water holding capacity of soil
6.	Measurement of matric potential using gauge and mercury type tensiometer
7.	Determination of soil-moisture characteristics curves
8.	Determination of saturated hydraulic conductivity by constant and falling head method
9.	Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
10.	Measurement of soil water diffusivity
11.	Estimation of unsaturated hydraulic conductivity

12.	Estimation of upward flux of water using tensiometer and from depth ground water table
13.	Determination of irrigation requirement of crops (calculations)
14.	Determination of effective rainfall (calculations)
15.	Determination of ET of crops by soil moisture depletion method16. Determination of water requirements of crops
16.	Measurement of irrigation water by volume and velocity-area method
17.	Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
18.	Determination of infiltration rate by double ring infiltrometer

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.

Conservation Agriculture — Agron-505

Credit :2(**1+1**)

Theory:

S. No.	Topics	No. of lectures
	UNIT I	
1.	**Conventional and conservation agriculture systems comparison & sustainability concerns**	1
2.	**Conservation agriculture: Historical background and present concept, global experiences, present status & future prospect of CA in India**	1
3.	**Adoption of conservation agriculture practices and constraints in it**	1
4.	**Nutrient management in conservation agriculture**	1
5.	**Water management in conservation agriculture**	1
6.	**Weed management in conservation agriculture**	1
	UNIT II	
7.	**Energy use, Insect-pest and disease management practices under CA**	2
8.	**Farm machinery: Its role, adoption and use in CA practices**	1
9.	Cover crop management in conservation agriculture & crop residue management in conservation agriculture	

10.	Climate change mitigation and conservation agriculture	1
11.	C-sequestration & its effect on eco system sustainability	1
	UNIT III	
12.	Soil health management, role of soil microbes in conservation agriculture	1
13.	CA in agroforestry systems,	1
14.	Role of Conservation Agriculture in rainfed & dryland regions	1
15.	Economic considerations in Conservation Agriculture	1
	Total	**16**

Practicals

Sl. No.	Description
1.	Study of long-term experiments on CA
2.	Evaluation of soil health parameters
3.	Estimation of C-sequestration
4.	Machinery calibration for sowing different crops
5.	Weed seedbank estimation under CA
6.	Energy requirements under CA
7.	Economic analysis of CA

Suggested Reading

- Arakeri HR and Roy D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
- Bisht JK, Meena VS, Mishra PK and Pattanayak A. 2016. Conservation Agriculture-An approach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi: 10/1007/978-981-10-2558-7.
- 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.
- Gracia-Torres L, Benites J, Martinez-Vilela A and Holgado-Cabera A. 2003. Conservation Agriculture- Environment Farmers experiences, innovations Socio-economic policy.
- Muhammad F and Kamdambot HMS. 2014. Conservation Agriculture. Publisher: Springer
- Cham Heidelberg, New Yaork Dordrecht London. Doi: 10.1007/978-3-319-11620-4.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. Principles of Agronomy. Kalyani.

Cropping Systems and Sustainable Agriculture — Agron-511

Credit: 2(**2+0**)

Theory:

S. No.	Topics	No. of lectures
	UNIT-I	
1.	**Cropping systems: definition, indices and its importance;**	1
2.	**Physical resources, soil and water management in cropping systems;**	1
3.	**Assessment of land use.**	1
4.	**Concept of sustainability in cropping systems**	1
5.	**Farming systems, definition, scope and objectives;**	1

6.	**Production potential under monoculture cropping,**	1
7.	**Multiple cropping**	1
8.	**Alley cropping**	1
9.	**Sequential cropping**	1
10.	**Intercropping,**	2
11.	**Mechanism of yield advantage in intercropping systems.**	1
	UNIT-II	
12.	**Above and below ground interactions**	1
13.	**Allelopathic effects;**	1
14.	**Competition relations;**	1
15.	**Multi-storied cropping**	1
16.	Yield stability in intercropping,	1
17.	Role of non-monetary inputs	1
18.	Crop diversification for sustainability;	1
19.	Role of organic matter in maintenance of soil fertility;	1
20.	crop residue management;	1
	UNIT-III	
21.	Fertilizer use efficiency	1
22.	Concept of fertilizer use in intensive cropping system.	1
23.	Advanced nutritional tools for big data analysis and interpretation.	1
24.	Plant ideotypes for drylands;	1
25.	plant growth regulators	1
26.	role of plant growth regulators in sustainability	1
27.	Artificial intelligence – concept and application.	1
	Total	**28**

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.

Dryland Farming and Watershed Management — Agron-512

Credit: 3(**2+1**)

Theory:

S. No.	Topics	No. of lectures
	UNIT-I	
1.	**Definition, concept and characteristics of dry land farming; dry land versus rainfed farming**	2

2.	**Significance and dimensions of dry land farming in Indian agriculture**	1
3.	**Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas**	2
4.	**Types of drought & it's effect on crops growth & yield**	1
5.	**Characterization of environment for water availability**	1
6.	**Stress physiology and resistance to drought**	2
7.	**Adaptation of crop plants to drought**	2
8.	**Drought management strategies**	2
	UNIT-II	
9.	**Crop planning for erratic and aberrant weather conditions**	2
10.	**Preparation of appropriate crop plans for dry land areas**	2
11.	Mid contingent plan for aberrant weather conditions	1
12.	Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage	1
13.	Concept of conservation tillage & role of CA practices in moisture and resourse conservation in dryland areas	2
14.	Tillage in relation to weed control and moisture conservation;	2
	UNIT-III	
15.	Techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics)	2
16.	Antitranspirants; role and effect on crop yield in water stress condition	1
17.	Soil and crop management techniques, seeding and efficient fertilizer use	2
18.	Concept of watershed resource management; Problems, approach and components of watershed resource management	3
	Total	**31**

Practicals

Sl. No.	Description
1.	Method of Seed Priming
2.	Determination of moisture content of germination of important dryland crops
3.	Determination of Relative Water Content and Saturation Deficit of Leaf
4.	Moisture stress effects and recovery behaviour of important crops
5.	Estimation of Potential ET by Thornthwaite method
6.	Estimation of Reference ET ny Penman Monteith Method
7.	Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
8.	Classification of climate by Koppen Method
9.	Estimation of water balance by Thornthwaite method
10.	Estimation of water balance by FAO method
11.	Assessment of drought
12.	Estimation of length of growing period
13.	Estimation of probability of rain and crop planning for different drought

	condition
14.	Spray of anti-transpirants and their effect on crops
15.	Water use efficiency
16.	Visit to dryland research stations and watershed projects

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.

Principles and Practices of Organic Farming — Agron-513

Credit: 3(**2+1**)

Theory:

S. No.	Topics	No. of Lectures
	UNI- I	
1.	**Organic farming – concept, definition and future prospects**	1
2.	**Organic farming : relevance to India and global agriculture**	1
3.	**Principles of organic agriculture**	1
4.	**Standard of organic farming**	1
5.	**Organic farming and sustainable agriculture**	1
6.	**Selection and conversion of land**	1
7.	**Soil and water management – land use, conservation tillage**	1
8.	**Shelter zones, hedges**	1
9.	**Pasture management,**	1
10.	**Agro-forestry**	1

11.	**Organic farming and water use efficiency;**	1
12.	**Soil fertility**	1
13.	**Nutrient recycling**	1
14.	**Organic residues**	1
15.	**Organic manures**	1
	UNIT-II	
16.	**Composting**	1
17.	**Soil biota and decomposition of organic residues**	1
18.	**Earthworms and vermicompost**	1
19.	**Green manures**	1
20.	**Biofertilizers**	1
21.	Bio gas technology	1
22.	Farming systems,	1
23.	Selection of crop and crop rotations	1
24.	Multiple and relay cropping systems	1
25.	Intercropping in relation to maintenance of soil productivity.	1
	UNIT-III	
26.	Control of weeds, diseases and insect pest management,	1
27.	biological agents and pheromones,	1
28.	Biopesticides	1
29.	Socio-economic impacts of organic farming	1
30.	Marketing and export potential or organic farming	1
31.	Inspection, certification, labeling and accreditation procedures;	1
32.	Organic farming and national economy.	1
	Total	**32**

Practicals

S. No.	Description
1.	Method of making compost by aerobic method
2.	Method of making compost by anaerobic method
3.	Method of making vermicompost
4.	Identification and nursery raising of important agro-forestry tress and tress for shelter belts
5.	Technique of treating legume seeds with *Rhizobium* cultures
6.	Technique of treating seeds with use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
7.	Visit to a biogas plant
8.	Visit to an organic farm
9.	Visit to an industry to understand the quality standards, inspection, certification, packaging and labelling process of organic produce under organic production system

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.
- Joshi M. 2016. New Vistas of Organic Farming. Scientific Publishers
- Lampin N. 1990. Organic Farming. Press Books, lpswitch, UK.
- Palaniappan SP and 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.
- Subba Rao NS. 2002. Soil Microbiology. Oxford & IBH.
- Trivedi RN. 1993. A Text Book of Environmental Sciences, Anmol Publ.
- Veeresh GK, Shivashankar K and 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 and Swift MJ. 1994. The Biological Management of Tropical Soil Fertility. TSBF & Wiley.

Agricultural Economics

Micro Economics Theory and Application **AEC-501**
Credit Hrs: 3(3+0)
Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Scarcity and Choice; Production possibility frontier, Positive and normative economics**	**1**
2.	**Concepts of opportunity cost, Demand and Supply, determinants of individual demand/supply; demand/ supply schedule and demand/ supply curve**	**3**
3.	**Market versus individual demand/ supply; shifts in the demand/ supply curve**	**1**
4.	**Cardinal Utility Approach – Ordinal Utility Approach**	**1**
5.	**Budget sets and Preferences under different situations–Hicks and Slutsky income and substitution effects**	**2**
6.	**Applications of Indifference curve approach – Revealed Preference Hypothesis – Consumer surplus**	**2**
7.	**Derivation of Demand curve – Elasticity of demand – Demand and supply together**	**1**
8.	**Prices allocate resources; controls on prices – price floor and price ceiling – applications in agriculture**	**2**
	Unit-II	
9.	**Production functions: single variable - average and marginal product, variable proportions, stages of production**	**2**
10.	**Two variables-iso-quants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization**	**2**
11.	**Elasticity of substitution. Expansion path and the cost function Concept of economic cost**	**2**
12.	Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves	1
13.	Economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit	2
14.	Behaviour of profit maximizing firms and the production process-Perfect competition: Equilibrium of the market	1
15.	Long run industry supply, applications: effects of taxes and subsidies; Monopoly	2
	Unit-III	
16.	Equilibrium; supply; Multiplan firm; monopoly power; deadweight loss; price discrimination	2
17.	Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition	2
18.	Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg‘s model, Bertrand model; Oligopoly	3

19.	Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product)	2
20.	Demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent	2

Suggested Reading:

- Koutsoyiannis A. Modern Micro Economics. Macmillan Press Ltd
- Richard A. Bilas, Micro Economic Theory.
- Leftwich Richard H. The Price System and Resources Allocation
- Allen CL. A Frame Work of Price Theory.

Agricultural Production Economics AEC-502

Credit Hrs.: 2(1+1)

Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Nature, scope and significance of agricultural production economics**	**02**
2.	**Agricultural production processes, character and dimensions- spatial, temporal, Centrality of production functions**	**01**
3.	**Assumptions of production functions, commonly used forms, Properties, limitations, specification, estimation and interpretation of commonly used production functions**	**02**
4.	**Factors of production, classification, interdependence, and factor substitution**	**01**
	Unit-II	
5.	**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**	**02**
6.	Cost functions and cost curves, components, and cost minimization	01
7.	Duality theory, cost and production functions and its applications	01
8.	Derivation of firm's input demand and output supply functions, Economies and diseconomies of scale	01
	Unit-III	
9.	Technology in agricultural production, nature and effects and measurement	01
10	Measuring efficiency in agricultural production Technical, allocative and economic efficiencies	01
11.	Yield gap analysis-concepts-types and measurements.	01
12.	Nature and sources of risk, modelling and coping strategies	01

Practical

S.No.	Topics
1.	Different forms of production functions
2.	Specification, estimation and interpretation of production functions

3.	Returns to scale, factor shares, elasticity of production
4.	Physical optima-economic optima
5.	Least cost combination
6.	Optimal product choice
7.	Cost function estimation, interpretation
8.	Estimation of yield gap
9.	Incorporation of technology in production functions
10.	Measuring returns to scale-risk analysis.

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.

Agricultural Marketing and Price Analysis **AEC-503**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**New Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides.**	**3**
2.	**Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation**	**2**
3.	**Marketing Efficiency - Structure Conduct and Performance analysis -**	**2**
4.	**Vertical and Horizontal integration-Integration over space, time and form-Vertical co-ordination.**	**1**
	Unit-II	
5.	**Different Forms of marketing: Co-operatives Marketing – APMC Regulated Marketing - Direct marketing,**	**2**
6.	**Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing**	**2**
7.	Organized retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -	1
8.	Performance and Strategies -Market infrastructure needs, performance and Government role-Value Chain Finance.	2
	Unit-III	
9.	Introduction to Commodities markets and future trading-Basics of commodity futures-Operation Mechanism of Commodity markets	1
10.	Price discovery-Hedging and Basis-Fundamental analysis	1
11.	Technical Analysis–Role of Government/SEBI in promoting commodity	1

	trading and regulatory measures.	
12.	Role of Information Technology and Market Intelligence in marketing of agricultural commodities, -	2
13.	Electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC).	2
14.	Price forecasting–time series analysis–time series models–spectral analysis.	1
15.	Price policy and economic development–non-price instruments	1

Practical:

S.No.	Topics
1.	Supply and demand elasticity's in relation to problems in agricultural marketing
2.	Price spread and marketing efficiency analysis
3.	Marketing structure analysis through concentration ratios.
4.	Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products
5.	Supply Chain Analysis-quantitative estimation of supply chain efficiency.
6.	Market Intelligence–Characters, Accessibility, and Availability Price forecasting
7.	Online searches for market information sources and interpretation of market intelligence reports – commodity outlook.
8.	Technical Analysis for important agricultural commodities
9.	Fundamental Analysis for important agricultural commodities
10	Presentation of the survey results and wrap-up discussion.

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

Macro Economics and Policy Economics **AEC-504**
Credit Hrs: 2(2+0)
Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Basic concepts and scope of Macro-economics**	01
2.	**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**	02
3.	**Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices**	03

4.	**Simple Keynesian model of income determination; Keynesian Multiplier- aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises)**	02
	Unit-II	
5.	**Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference Theory – Liquidity Trap;**	02
6.	Asset market equilibrium- LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy	02
7.	Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model,	02
	Unit-III	
8.	Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.	01
9.	Inflation: Nature, Effects and control; Types of inflation demand pull, cost push- stagflation, core inflation, hyperinflation;	02
10.	Phillips curve	01

Suggested Reading:

- Stonier & Hegue. A Text Book of Economic Theory
- Samuelson PA. 1948. Foundation of Economic Analysis. Harvard University Press
- MC Vaish Allid. 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

Econometrics **AEC-505**

Credit Hrs: 3(2+1)

Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis**	02
2.	**Basic two variable regression – assumptions estimation and interpretation approaches to estimation**	02
3.	**OLS and their properties – extensions to multi-variable models-**	02
	Unit-II	
4.	**Multiple regression estimation and interpretation**	02
5.	Violation of assumptions – identification, consequences and remedies for Multicollinearity	01
6.	Heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification	02

	Unit-III	
7.	Use of dummy variables	01
8.	Introduction to simultaneous equations- identification problem	02

Practical

S.No.	Topics
1.	Single equation two variable model specification and estimation
2.	Hypothesis testing transformations of functional forms and OLS application
3.	Estimation of multiple regression model
4.	Testing and correcting specification errors
5	Testing and managing Multicollinearity
6.	Estimation of regressions with dummy variables

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.

Agricultural Finance and Project Management AEC-507

Credit Hrs: 3(2+1)

Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector**	1
2.	**Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs**	2
3.	**District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.**	2
4.	**Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit**	1
5.	**Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals**	1
6.	**Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening**	2
	Unit-II	
7.	**Financial Decisions – Investment, Financing, Liquidity and Solvency**	1
8.	**Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account**	2
9.	**Ratio Analysis and Assessing the performance of farm/firm**	1

10.	Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects	1
11.	Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures	2
12.	Time value of money – Use of discounted measures - B-C ratio, NPV and IRR	2
	Unit-III	
13.	Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques – PERT and CPM	2
14.	Risks in financing agriculture. Risk management strategies and coping mechanism	2
15.	Crop Insurance programmers – review of different crop insurance schemes - yield loss and weather – based insurance and their applications	3

Practical:

S.No.	Topics
1.	Development of Rural Institutional Lending
2.	Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving
3.	An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme
4.	Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions
5.	Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements
6.	Performance of Micro Financing Institutions
7.	NGO's and Self-Help Groups, Identification and formulation of investment projects
8.	Project appraisal techniques–Undiscounted Measures and their limitations
9.	Project appraisal techniques – Discounted Measures
10.	Network techniques – PERT and CPM for project management
11.	Case Study Analysis of an Agricultural project
12.	Financial Risk and risk management strategies – crop insurance schemes
13	Financial instruments and methods – E banking, Kisan Cards and core banking

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.

Linear Programming **AEC-508**

Credit Hrs: 2(1+1)

Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Decision Making- Concepts of decision making, introduction to quantitative tools**	**01**
2.	**Introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.**	**02**
3.	**Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems**	**01**
	Unit-II	
4.	**Formulation of farms and non-farm problems as linear programming models and solutions**	**01**
5.	Extension of Linear Programming models: Variable resource and price programming	**01**
6.	Transportation problems, recursive programming, dynamic programming	**01**
	Unit-III	
7.	Game Theory- Concepts of game theory, two-person constant sum	**01**
8.	Zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.	**02**

Practical

S.No.	Topics
1.	Graphical and algebraic formulation of linear programming models.
2.	Solving of maximization and minimization problems by simplex method.
3.	Formulation of the simplex matrices for typical farm situations.

Research Methodology for Social Sciences **AEC-509**

Credit Hrs: 2(1+1)

Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Importance and scope of research in agricultural economics. Types of research – Fundamental vs. Applied**	1
2.	**Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process**	1
3.	**Hypothesis – meaning – characteristics – types of hypothesis – review of literature – setting of Course Objective and hypotheses – testing of hypothesis**	1
4.	**Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose**	1

	Unit-II	
5.	**Project proposals – contents and scope – different types of projects to meet different needs, trade-off between scope and cost of the study**	1
6.	**Research design and techniques, types of research design**	1
7.	Data collection – assessment of data needs – sources of data collection – discussion of different situations.	1
8.	Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques	1
	Unit-III	
9.	Preparation of schedule – problems in measurement of variables in agriculture	1
10.	Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.	1
11.	Data coding, tabulation, cleaning. –Multivariate analysis –factor analysis' PCA' cluster analysis.	1
12.	Universal procedures for preparation of bibliography – writing of research articles	1

Practical:

S.No.	Topics
1.	Exercises in problem identification
2.	Project proposals – contents and scope.
3.	Formulation of Objective and hypotheses
4.	Assessment of data needs – sources of data – methods of collection of data
5.	Methods of sampling – criteria to choose – discussion on sampling under different situations.
6.	Scaling Techniques – measurement of scales.
7.	Preparation of interview schedule
8.	Field testing. Method of conducting survey.
9.	Exercise on coding, editing, tabulation and validation of data
10.	Preparing for data entry into computer.
11.	Hypothesis testing – Parametric and Non-Parametric Tests
12.	Exercises on format for Thesis/ Report writing
13.	Presentation of the results

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

Commodity Future Trading **AEC-514**
Credit Hrs: 2(2+0)
Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**History and Evolution of commodity markets**	**2**
2.	**Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets**	**2**
3.	**Speculatory mechanism in commodity futures**	**2**
	Unit-II	
4.	**Transaction and settlement – delivery mechanism - role of different agents - trading strategies -potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.**	**4**
5.	**Risk in commodity trading, importance and need for risk management measures**	**2**
6.	Managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features	2
	Unit-III	
7.	Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges - FMC and its role.	4
8.	Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing.	4
9.	Introduction to technical analysis software – analyzing trading pattern of different commodity groups.	2

Suggested Reading:

- Kaufman PJ. *The Concise Handbook of Futures Markets*: Jhon Wiley & Sons
- Purcell WD. *Agricultural Futures and Options: Principles and Strategies*: MacMillan Publications
- Wasendorf RR & McCaffery *All About Commodities from the Inside Out.* McGraw Hill

Agricultural Extension Education

Extension Landscape **EXT-501**
Credit Hrs.: 2(2+0)
Thoery:

S.No.	Topics	No. of Lecture
	Unit-I **A. Challenges Before Extension and Advisory Services (EAS)**	
1.	**Extension and Advisory Services (EAS) and Farmer centric Natural Resource Management (NRM)**	1
2.	**Gender Mainstreaming and Nutri- sensitive Extension**	1
3.	**Linking farmers to markets and value chain extension.**	1
4.	**Up-scaling Climate Smart Agriculture and Urban and peri-urban farming**	1
5.	**Value chain extension for organizing farmers and strengthening value chains.**	1
6.	**Mitigating and busting the Rural Migration and Attracting and retaining youth in agriculture**	1
7.	**Farmer distress and suicides: The role of extension in tackling farm distress.**	1
	Unit-I **B. New Functions and New Capacities**	
8.	**Organizing producers into groups for collective decision-making on NRM and markets.**	1
9.	**Mediating conflicts and building consensus.**	1
10.	**Networking and partnership development, including multi-stakeholder platforms**	1
11.	**New capacities for EAS at individual (lower, middle, senior management), organizational, and enabling environment levels.**	1
12.	**Core competencies and varied mechanisms for capacity development beyond training**.	1
	Unit-II **A. Pluralism in EAS**	
13.	**Pluralism in extension delivery: The role of the private sector (input firms, agri-businesses, consultants).**	1
14.	**Role of NGOs and Civil Society Organizations (CSOs) in providing extension services.**	1
15.	**Producer Organizations: Their role, strengths, and weaknesses in strengthening extension services.**	1
16.	**Role of media and ICT advisory service providers.**	1
	Unit-II B. From the Linear Paradigm to Systems Paradigm	
17.	Diffusion of Innovations paradigm: Strengths and limitations.	1
18.	Multiple sources of innovation: Farmer and institutional innovation, and farmer participation.	1
19.	Agricultural Knowledge and Information Systems (AKIS) and	1

	Agricultural Innovation Systems (AIS).	
20.	Redefining innovation: The role of EAS in AIS, moving to intermediation and brokering.	1
21.	Innovation Platforms and Innovation Management.	1
22.	Rethinking communication in the innovation process: Network building, social learning, power, and conflict.	1
	Unit-III A. Evolving Extension Approaches	
23.	Evolution and features of extension approaches: Transfer of technology, educational, and farmer participatory approaches.	1
24.	Demand-driven, market-led (value chain), and gender-sensitive extension.	1
25.	Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia, and North America.	1
26.	Networking for strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.	1
	Unit-III B. Changes in Governance, Funding, and Delivery	
27.	Changes in governance and funding- (public withdrawal from extension provision and privatization.	1
28.	Decentralization of extension services and Extension and the Sustainable Development Goals (SDGs).	1
	Unit-III C. Challenges in Managing Pluralistic Extension System	
29.	Managing pluralism and coordination of pluralistic extension provision, including Public-Private Partnerships and the role of local governments and producer organizations.	1
30.	Convergence in extension planning and delivery.	1
31.	Financing Extension (mobilizing resources), Monitoring and Evaluation of Extension	1
32.	Strengthening the extension policy interface by generating evidence on impact and policy-relevant communication	1

Suggested Reading

Adolph B. 2011. *Rural Advisory Services World wide: A Synthesis of Actors and Issues. GFRAS*: Lindau, Switzerland. https://www.g-fras.org/en/knowledge/gfras-publications.html?download=6: rural-advisory-services-worldwide&start=40

Ashok G, Sharma P, Anisha S and Prerna T. 2018. *Agriculture Extension System in India Review of Current Status, Trends and the Way Forward.* Indian Council for Research on International Economic Relations (ICRIER). http://icrier.org/pdf/Agriculture-Extension-System-in-India-2018.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

Bentley J, Chowdhury A and David S. 2015. *Videos for Agricultural Extension.* Note 6. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/6-video-for-agricultural-extension.html #SNote1

Bingen RJ and Simpson BM. 2015. *Farmer Organizations and Modernizing Extension and Advisory Services*. MEAS Discussion Paper. http://meas.illinois.edu/wp-content/uploads/2015/04/Bingen-Simpson-2014-FarmerOrganizations-MEAS-Discussion-Paper.pdf

Bitzer V, Wennink B and de Steenhuijsen PB. 2016. *The governance of agricultural extension systems*. KIT Working Paper 2016: 1.http://213ou636sh0ptphd141fqei1.wpengine.netdna-cdn.com/sed/wpcontent/uploads/sites/2/2016/03/WPS_1-2016-web.pdf

Bitzer V, Wongtschowski M, Hani M and Blum M. 2016. *New directions for inclusive Pluralistic Service Systems.* In New Directions for Inclusive Pluralistic Service Systems Rome (Italy). FAO. http://www.fao.org/3/a-i6104e.pdf

Burton ES & Kristin D. 2014. *Status of Agricultural Extension and Rural Advisory Services Worldwide.* GFRAS: Lindau, Switzerland. http://www.g-fras.org/en/knowledge/gfras-publications.html?download=391: status-of-agricultural-extension-and-rural-advisory-services-worldwide

Christoplos I. 2010. *Mobilizing the potential of rural and agricultural extension*. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/012/i1444e/i1444e.pdf

Colverson KE. 2015. *Integrating Gender into Rural Advisory Services.* Note 4. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/integrating-gender-into-rural-advisory- services.html#SNote1

David S. 2018. *Migration and rural advisory services.* GFRAS Issues Paper 2. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/gfras-publications/category/97-gfras-issues-papers.html?download=856: migration-and-rural-advisory-services

Davis K and Heemskerk W. 2012. *Coordination and Collective Action for Agricultural Innovation* Overview Module 1 Investment in Extension and Advisory Services as Part of Agricultural Innovation Systems. In Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank. © World Bank.

http://siteresources.worldbank.org/INTARD/Resources/335807-1330620492317/9780821386842ch3.pdf

FAO. 2016. *New directions for inclusive Pluralistic Service Systems*. Report of FAO Expert Consultation. Food and Agriculture Organization of the United Nations and Royal Tropical Institute, Rome. http://www.fao.org/3/ai6103e.pdf

FAO.2017. *Climate-Smart Agriculture Sourcebook.* Available at: http://www.fao.org/3/a-i3325e.pdf

Faure G, Pautrizel L, de Romémont A, Toillier A, Odru M and Havard M. 2015. *Management Advice for Family Farms to Strengthen Entrepreneurial Skills***.** Note 8. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g- fras.org/en/good-practice-notes/management-advice-for-family-farms-to-strengthen- entrepreneurial-skills.html#SNote8

GFRAS. 2012. *Building Knowledge Systems in Agriculture Five Key Areas for Mobilising the Potential of Extension and Advisory Services.* Global Forum for Rural Advisory Services. http://www.fao.org/uploads/media/1_gfras_positionpaper_final2_websmallpdf%20com%20(1).pdf

GFRAS. 2015. *Producer organisations in rural advisory services: Evidence and experiences.* Position Paper. Lindau: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/593-producer-organisations-in-rural-advisory-servicesevidence-and-experiences.html

GFRAS. 2016. *Five Key Areas for Mobilising the Potential of Rural Advisory Services.* GFRAS Brief 1. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/knowledge/

gfras-publications.html?download=4: five-key-areas-for-mobilising-the-potential-of-rural-advisory-services.

GFRAS.2016. *The New Extensionist Learning Kit*. http://g-fras.org/en/knowledge/new-extensionist-learningkit-nelk.html#module-1-introduction-to-the-new-extensionist

GRFAS. 2014. *Policy Compendium.* http://www.g-fras.org/en/policy-compendium.html

Gwyn EJ and Garforth C. nd. *The history, development, and future of agricultural extension.*

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Jennings JR, Packham RG and Woodside D. 2011. *Shaping change: natural resource management, agriculture and the role of extension.* Australasia Pacific Extension Network. http://www.apen.org.au/shaping-change

Leeuwis C with A W van den Ban. 2004. *Communication for rural innovation: Rethinking agricultural extension.* John Wiley & Sons.

Magdalena Blum and Sanne Chipeta. 2016. *Innovative Financing Mechanisms for Demand-driven Agricultural Advisory Services.* Gfras good practice note for extension and advisory services 21. Global Forum for Rural Advisory Services. https://www.g-fras.org/en/good-practice-notes/20-innovative-financing-mechanisms.html#SNote8

Manfre C, Rubin D and Nordehn C. 2017. *Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes.* A three part toolkit. Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES). http:// www.culturalpractice.com/wp-content/uploads/Introduction-to-the-Toolkit-Final-10_17.pdf

Mittal N, Sulaiman RV and Prasad RM. 2016. *Assessing capacity needs of Extension and Advisory Services: A Guide for Facilitators.* Agricultural Extension in South Asia (AESA). http:// crispindia.org/wpcontent/uploads/2015/09/Facilitators-Guide-Final-LR.pdf

Posthumus H and Wongtschowski M. 2014. *Innovation Platforms.* Note 1. GFRAS good practice note for extension and advisory services. GFRAS: Lindau, Switzerland. https://www.g- fras.org/en/good-practice-notes/innovation-platforms.html#SNote1

Rajalahti R, Janssen W and Pehu E. 2008. *Agricultural innovation systems: From diagnostics toward operational practices.* Agriculture & Rural Development Department, World Bank. https://agrilinks.org/sites/default/files/resource/files/ARDDiscussionPaper38.pdf

Rao S. 2015. *Using Radio in Agricultural Extension.* Note 18. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/using-radio-in-agricultural-extension.html#SNote8

Rivera W and Zijp W. 2002. *Contracting for Agricultural Extension-International Case Studies and Emerging Practices.* CABI Publishing.

Saravanan R and Suchiradipta B. 2015. *mExtension – Mobile Phones for Agricultural Advisory Services.* Note 17. Gfras good practice note for extension and advisory services. GFRAS: Lindau, Switzerland.

https://www.g-fras.org/en/good-practice-notes/mextension.html#SNote17

Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and Anandaraja N. 2015. *Web Portals for Agricultural Extension and Advisory Services.* Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/

Saravanan R, Sulaiman RV, Davis K and Suchiradipta B. 2015. *Navigating ICTs for Extension and Advisory Services.* Note 11. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://agrilinks.org/sites/default/files/resource/files/gfras-ggp-note11_navigating_icts_for_ras_1.pdf

Sulaiman RV 2015. *Agricultural Innovation Systems.* Note 13. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/good-practice-notes/agricultural-innovation-systems.html#SNote8

Sulaiman RV and Davis K. 2012. *The New Extensionist: Roles, strategies, and capacities to strengthen extension and advisory services.* In Lindau, Switzerland: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/157-thenew-extensionist

Suvedi M and Kaplowitz MD. 2016. *What Every Extension Worker Should Know: Core Competency Handbook.* Michigan State University. Department of Community Sustainability. https://agrilinks.org/library/what-every-extensionworker-should-know-core-competency-handbook

Swanson BE and Rajalahti R. 2010. *Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing. Transforming, and Evaluating Extension Systems.* Agriculture and Rural Development Discussion Paper; No. 45. World Bank, Washington, DC. © World Bank. http://siteresources.worldbank.org/INTARD/Resources/Stren_combined_web.pdf

Swanson BE. 2008. *Global Review of Good Agricultural Extension and Advisory Service Practices.* Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/ pdf/011/i0261e/i0261e00.pdf

Terblanche S and H Ngwenya. 2017. *Professionalisation of Rural Advisory Services.* Note GFRAS Global Good Practice Notes for Extension and Advisory Services. GFRAS: Lausanne, Switzerland. https://www.g-fras.org/en/good-practice-notes/27-professionalisation.html#SNote27

World Bank. 2006. *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems.* Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/7184

Websites

AESA- Agricultural Extension in South Asia http://www.aesanetwork.org/
FAO- Food and Agricultural Organisation (Research and Extension) http://www.fao.org/research-and-extension/en/
GFRAS- Global Forum for Rural Advisory Services http://www.g-fras.org/en/
INGENEAS- Integrating Gender and Nutrition within Agricultural Extension Services https://ingenaes.illinois.edu/
IFPRI- International Food Policy Research Institute (Extension) http://www.ifpri.org/topic/agricultural-extension
KIT- Royal Tropical Institute (KIT)-Sustainable Economic Development https://www.kit.nl/sed/
WUR- Wageningen University and Research Research (Knowledge, Technology and Innovation Group (KTI)) https://www.wur.nl/en/Research-Results/Chair-groups/Social-Sciences/ KnowledgeTechnology-and-Innovation-Group.htm

Applied Behaviour Change — EXT-502

Credit Hrs.: 3(2+1)

Theory:

S.No.	Topics	No. of Lecture
	Unit-I **A. Foundations of Human Behaviour**	
1.	**Foundations of human behaviour focusing on its definition, importance, and biological bases such as nervous system, brain, endocrine system, and genes**	1
2.	**Individual variations covering theories of intelligence, ability, and creativity**	1

3.	**Personality and moral development with personality theories, measurement tools, and concepts like self-concept, self-esteem, and self-worth**	1
4.	**Motivation and perception explaining theories of motivation and how we perceive others through impressions, attitudes, and opinions**	1
5.	**Emotions and emotional intelligence discussing types, functions, and methods of measuring EI**	1
	Unit-I **B. Cognitive Processes affecting Human Behaviour**	
6.	**Sensory organs and cognitive processes examining the role of sensory inputs in attention, perception, and memory**	1
7.	**Remembering and forgetting focusing on storage, retrieval, and mechanisms of forgetting**	1
8.	**Knowledge and expertise with foundations and theories of knowledge acquisition and expertise development.**	1
9.	**Consciousness and learning introducing types of consciousness, sleep, dreams, and basics of learning and memory**	1
10.	**Complex cognitive processes covering concept formation, thinking, problem-solving, and transfer of learning**	1
	Unit-II **A. Information Processing**	
11.	**Introduction to information processing with meaning and principles of information handling**	1
12.	**Models of memory including Waugh and Norman's model and Atkinson and Shiffrin's stage model**	1
13.	**Other information processing models such as Bloom's Taxonomy and Sternberg's approach.**	1
14.	**Attention and perception focusing on meaning, types, theories, and models**	1
	Consciousness in detail with an in-depth exploration of its concepts.	1
	Unit 2B. Learning	
15.	**Learning foundations and approaches describing various theories and frameworks**	1
16.	**Cognitive and behavioral learning approaches with focus on cognitive principles and behavioral foundations**	1
17.	Behavioral theories of learning including classical conditioning, operant conditioning, and applied behavior analysis	1
18.	Social cognitive and constructivist learning covering self-regulated learning and social cognitive theory	1
19.	Learning styles explaining meaning, types, and applications	1
	Unit 3A. Judgement, Choice and Decision-making	
20.	Human judgement defining its nature, randomness of situations, and models	1
21.	Choice describing criteria, theories, and models of human choice	1
22.	Choice architecture focusing on principles and applications	1
23.	Decision-making with steps, problem analysis, and techniques in various contexts	1
24.	Advanced decision-making examining complexities and techniques under different circumstances	1

	Unit-III B. Attitudes and Influence	
25.	Attitudes defining meaning, types, assumptions, theories, and methods of attitude change	1
26.	Relating to others explaining liking, attraction, helping behaviour, prejudice, discrimination, and aggression	1
27.	Liking and attraction with definitions, types, and related theories.	1
28.	Persuasion defining its meaning with theories and techniques	1
29.	Social influence and groups covering conformity, compliance, and obedience	1
	Unit 3C. Social Judgement, Social Identity and Inter-Group Relations	
30.	Social judgement and identity discussing stereotyping, attribution theory, and types of social identity	1
31.	Groups and inter-group relations exploring group processes, sustainability, inter-group dynamics, and social learning theory	1

Practicals

S. No.	Description
1.	Understanding Perception- Attentional Blink and Repetition Blindness exercise.
2.	Understanding attention- Testing selective attention capacity and skills and processing skill ability through Stroop Test
3.	Hands on experience in the techniques for assessing creative thinking- divergent and convergent thinking
4.	Lab exercise in applying Maslow's need hierarchy to assess motivation
5.	Assessing learning styles through Barsch and Kolb inventories
6.	Practical experience in building self-esteem
7.	Assessment of emotional intelligence
8.	Exercises in problem solving
9.	Measuring self-concept using psychometric tools
10.	Assessment of attitudes
11.	Hands on experience in methods of persuasion
12.	Field experience in assessing social judgement
13.	Simulation exercise to understand decision-making under different situations
14.	Exercise in rational decision-making.

Suggested Reading

Eiser J, Richard. 2011. *Social Psychology: Attitudes, Cognition and Social Behaviour.* Cambridge: Cambridge University Press. (First Edition, 1986))

Eysenck MW and Keane M T. 2010. *Cognitive psychology: A student's handbook.* Sixth Edition, Hove: Psychology Press.

Feldman RS. 2008. *Essentials of understanding psychology* (7th ed.). Boston: McGraw-Hill. Gilovich T, Keltner D, and Nisbett RE. 2011. *Social psychology*. New York: W.W. Norton & Co. Moreno R. 2010. *Educational Psychology*. Hoboken, NJ: John Wiley & Sons Inc.

Nevid JS. 2012. *Essentials of psychology: Concepts and applications* Belmont, CA: Wadsworth, Cengage Learning.

Rachlin H. 1989. *Judgment, decision, and choice: A cognitive/behavioral synthesis.* New York: W.H. Freeman.

Organisational Behaviour and Development **EXT-503**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Introduction to organizations-concept and characteristics of organizations, Typology of organizations**	**1**
2.	**Theories of organizations: nature of organizational theory. Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/ analysis**	**1**
3.	**Concepts of Organizational Behaviour, Scope, Importance, Models of Organizational Behaviour**	**1**
4.	**Individual Behaviour in Organizations-Introduction, Self-awareness, Perception, Attribution and Learning**	**1**
5.	**Systems approach to studying organization needs and motives**	**1**
6.	**Attitude, values and ethical behavior**	**1**
7.	**Personality, Motivation-Concept & Theories, Managing motivation in organizations**	**1**
8.	**Foundations of group, group Behaviour and group dynamics**	**1**
9.	**Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations**	**1**
10.	**Teams in Organizations-Team building, experiential exercises, Interpersonal Communication and Group**	**1**
11.	**Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence**	**1**
12.	**Managing Conflict and Negotiation skills, Job/ stress management, Decision-making, problem-solving techniques.**	**1**
	Unit-II	
13.	**Productive Behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimension, determinants and measurement**	**1**
14.	**Job satisfaction and organizational commitment - meaning, dimensions and measures roles and role clarity**	**1**
15.	**Occupational stress – meaning, sources, theories and models, effects, coping mechanism, effects and management**	**1**
16.	**Occupational stress in farming, farmer groups/ organizations, research and extension organizations**	**1**
17.	**Occupational stress – meaning, sources, theories and models, effects, coping mechanism, effects and management**	**1**
18.	**Occupational stress in farming, farmer groups/ organizations, research and extension organizations**	**1**
19.	Organizations Structure- Need and Types, Line & staff, functional, committee	**1**
20.	Project structure organizations, centralization & decentralization, Different stages of growth and designing the organizational structure	**1**
21.	Organizational Design- Parameters of Organizational Design, Organization and Environment	**1**
22.	Organizational Strategy, Organization and Technology, Power and	**1**

	Conflicts in Organizations	
23.	Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.	**1**
	Unit-III	
24.	Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.	**1**
25.	Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem	**1**
26.	Diagnostic models, open systems, individual level group level and organizational level diagnosis; Action-collection and analysis for diagnostic information	**1**
27.	Feeding back the diagnosed information and interventions	**1**
28.	Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.	**1**
29.	Organizational Development Interventions- Organizational Development Interventions Meaning, Importance, Characteristics	**1**
30.	Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.	**1**
31.	Who is OD consultant? Types of OD consultants and their advantages, qualifications	**1**
32.	Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners' skills and activities.	**1**

Practicals

Sl. No.	Description
1.	Case Analysis of organization in terms of process – attitudes and values, motivation, leadership.
2.	Simulation exercises on problem-solving.
3.	Study of organizational climate in different organizations.
4.	Study of organizational structure of development departments.
5.	Study of departmentalization, span of control, delegation of authority, decision-making patterns.
6.	Study of individual and group behaviour at work in an organization.
7.	Conflicts and their management in an organization.
8.	Comparative study of functional and nonfunctional organizations and drawing factors for organizational effectiveness.
9.	Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization

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. Tata-McGraw 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.

Research Methodology in Extension **EXT-504**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	**Nature of Behavioural Research, Methods of knowing; Science and scientific method, Behavioural research- Concept, aim, goals, objectives and types based on applications, objectives and inquiry, Characteristics and Paradigms of research**	1
2.	**Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate**	1
3.	**Role of behavioural research in extension; Careers in behavioural research, Basic steps in behavioural research, formulating a Research Problem, Identifying the variables and hypotheses, formulating research designs, methods and tools, Selecting sample**	1
4.	**Collecting data; Analyzing and Interpreting the Data, Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals**	1
5.	**The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems**	1
6.	**Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem;**	1
7.	**Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions**	1
8.	**Techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives**	1

9.	**Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical**	**1**
10.	**Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literature**	**1**
11.	**Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables**	**1**
12.	**Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypothesis**	**1**
	UNIT-II	
13.	**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.**	**1**
14.	**Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.**	**1**
15.	**Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Criteria for selecting a suitable Research Design**	**1**
16.	**Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis;**	**1**
17.	**Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research;**	**1**
18.	**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.**	**1**
19.	Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulation. Research methods:	**1**
20.	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.	**1**
21.	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	**1**
22.	Types of sampling, Methods of drawing a random sample, Sampling with or without replacement,	**1**
23.	Types of sampling- Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified	**1**

	random sampling and Unequal probability Sampling	
24.	Non- probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling	**1**
	UNIT-III	
25.	Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalisation – Importance, Types of generalisations.	**1**
26.	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	**1**
27.	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.	**1**
28.	Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research.	**1**
29.	Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses;	**1**
30.	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;	**1**
31.	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	**1**
32.	Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analyzed data, Writing reports and research publications; Evaluation Methodology	**1**

Practicals

Sl. No.	**Description**
10.	Selecting a research problem and writing problem statement, Narrowing down research problem to purpose, research questions and objectives
11.	Choosing, evaluating and reviewing research literature
12.	Selection of variables through construct conceptualisation and defining variables
13.	Choosing research design based on research problem, choosing right sampling method and estimating sample size
14.	Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides
15.	Writing a research proposal, Field data collection using research methods

	and tools
16.	Testing reliability and validity of research instruments
17.	Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research
18.	Writing report, writing of thesis and research articles, Presentation of reports

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-cum- Workshop organised 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-current-status-and-future-strategies-p-sethurman-sivakumar-and-rasheed-sulaiman-v-december- 2015/

Capacity Development **EXT-505**
Credit Hrs.: 3(2+1)
Theory:

S. No.	Description	No. of Lecture
	Unit-I (A) **Capacity Development–An Overview**	
1.	**Foundations of capacity development defining and differentiating training, capacity building, and capacity development along with core principles and three levels of capacities.**	1
2.	**Types and components of capacity building covering structured, semi-structured, unstructured, orientation, induction, refresher, online, and other methods along with programme components.**	1
3.	**The capacity development cycle providing an overview from needs assessment to evaluation.**	1
	Unit-I (B) **Capacity Development- Approaches and Strategies**	
4.	**The capacity development dilemma discussing challenges and choices between theory and practice, and structured and unstructured approaches**	1
5.	**Approaches in capacity development covering informative, participatory, experiential, and performance-based methods.**	1
6.	**Capacity development strategies including academic, laboratory, activity, action, personal, and organizational strategies**	1
	Unit-I (C) **Planning and Organization of Capacity Development Programmese**	
7.	**Designing and planning part 1 describing steps like selecting participants, determining needs, formulating goals, and outlining content.**	1
8.	**Designing and planning part 2 covering instructional activities, preparing design, evaluation forms, and follow-up activities**	1
9.	**Organizing the programme and stakeholder responsibilities describing operational arrangements before, during, and after with roles of stakeholders**	1
	Unit-I (D) **Planning and Organization of Capacity Development Programmes**	
10.	**The concept of need assessment introducing its importance in capacity development.**	1
11.	**Approaches in need analysis including performance analysis, task analysis, and competency studies.**	1
12.	**Needs surveys describing how to conduct surveys and their role in identifying gaps**	1
	Unit-II (A) **Capacity Development Needs Assessment Methods**	
13.	**Rational methods for data collection including observation, informal talks, and complaints.**	1
14.	**Empirical methods for data collection covering job analysis, performance evaluation, questionnaires, tests, and critical incident technique**	1

15.	**Task and gap analysis explaining task identification and gap analysis for need assessment**	1
	Unit-II (B) **Capacity Development Institutions**	
16.	**The role of the capacity developer defining types of trainers and their roles**	1
17.	**Qualities and skills of a good capacity developer focusing on intrapersonal, interpersonal skills, and essential qualities**	1
18.	**Roles of a capacity developer and institutional support describing roles like manager, facilitator, evaluator and institutional contributions**	1
	Unit-II (C) **Capacity Development Project Formulation**	
19.	Project proposal concept and meaning in the context of capacity development.	1
20.	Steps in project formulation covering review of past proposals, consultations, and evaluation reports.	1
21.	The format for writing a project proposal focusing on the Logical Framework Approach (LFA)	1
	Unit-II (D) **Capacity Development Methods and Tools**	
22.	Methods for capacity development part 1 covering lecture, discussion, and syndicate methods.	1
23.	Methods for capacity development part 2 describing seminars, conferences, symposiums, role-playing, and case studies.	1
24.	Methods for capacity development part 3 covering programmed instruction, laboratory methods, and factors for method selection.	1
	Unit-III (A) **Evaluation**	
25.	Capacity development programme evaluation defining meaning, importance, and purpose.	1
26.	Types of evaluation covering formative, summative, and Kirkpatrick's four levels of evaluation.	1
27.	The evaluation process and findings describing stages of evaluation, use of results, and statistical tools.	1
	Unit-III (B) **Impact Assessment**	
28.	Impact assessment defining meaning, need, features, and benefits.	1
29.	Indicators for impact assessment covering direct, indirect, quantitative, and qualitative indicators within the result chain.	1
30.	Methods of impact evaluation focusing on KOSA, job performance, organizational effectiveness, and stakeholder competency.	1
	Unit 3C. Human Resource Development	
31.	HRD meaning, importance, and benefits providing an overview of Human Resource Development.	1
32.	Types of HRD systems including career, work, and development systems.	1
33.	HRD sub-systems covering self-renewal and culture systems with their components.	1
34.	Components of an HRD system including performance appraisal,	1

	potential appraisal, and task, development, and socialization systems.	
35.	Functions of HRD and governance summarizing organizational and career development and governance role.	1

Practical

No.	Description
1.	Capacity development needs assessment exercise
2.	Capacity development project formulation exercise
3.	Planning organizing and conducting an extension capacity development programme
4.	Designing a programme
5.	Writing learning objectives
6.	Developing objectives into curriculum
7.	Training plan
8.	Organizing capacity development workshop
9.	Evaluation with pre- and post-training tests
10.	Training methods – Practicing each method mentioned in contents as group exercise

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, Kanalstra Be 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

DoP T. 2014. *Civil Services Competency Dictionary: Strengthening Human Resource Management of Civil Service*. Department of Personnel and Training, Government of India

FAO. 2010. *FAO Capacity Assessment Approach and Supporting Tools - Discussion Draft*, Food and Agriculture Organisation of the United Nations

FAO. 2012. *Capacity Development: Learning Module 2.* FAO Approaches to Capacity Development in Programming. Processes and Tools, Food and Agriculture Organisation of the United Nations

FAO .2012. *Corporate Strategy on Capacity Development*.

FAO. 2013. *Capacity Development: Learning Module 4*. Organization Analysis and Development Food and Agriculture Organisation of the United Nations

GFRAS. 2012. *The New Extensionist: Roles, Strategies, and Capacities to Strengthen Extension andAdvisory Services*, Global Forum for Advisory Services

GFRAS. 2015. *The New Extensionist: Core Competencies for Individuals*, GFRAS Brief 3. Horton D. 2002. *Planning, Implementing, and Evaluating Capacity Development*. ISNAR Briefing Paper 50.

ICAR 2015. *Training Policy 2015*, Indian Council of Agricultural Research.

IISD 2015. *Appreciative Inquiry and Community Development*. International Institute for Sustainable Development.

LENCD 2011. *How to assess existing capacity and define capacity needs*, Learning Network on Capacity Development.

Maguire. 2012. *Module 2: Agricultural Education and Training to Support Agricultural Innovation Systems. Overview. Agricultural Innovation Systems: An Investment Source book*. The World Bank.

Mbabu AN and Hall A. 2012. *Capacity Building for Agricultural Research For Development-Lessons from Practice in Papua New Guinea*. United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT). https://www.merit.unu.edu/archive/docs/hl/201302_Capacity%20Building%20for%20 Agricultural%20Research%20Development_Final.pdf

Mittal N, Sulaiman RV and Prasad R M. 2016. *Assessing Capacity Needs of Extension and Advisory Services a Guide for Facilitators*. Agricultural Extension in South Asia. http:// www.aesanetwork.org/assessing-capacity-needs-of-extension-and-advisory-services-a- guide-for-facilitators/

Mishra DC. 1990. *New Directions in Extension Training*. Directorate of Extension, Ministry of Agriculture, Govt. of India, New Delhi.

OECD/DAC. 2006. *The Challenge of Capacity Development: Working Towards Good Practice*, Organisation for Economic Cooperation and Development.

Pretty JN, Gujit I, Thompson J, and Scoones I. 1995. *A Trainer's Guide for Participatory Learning and Action*. IEED Participatory Methodology Series.

Rolf PL and Udai P. 1990. *Training for Development*, (3rd edn) by (West Hartford, Kumarian Press, 1990, pp. 333.

SIDA.2000. *Capacity Development*. SIDA Working Paper No. 4. Analysis of Needs for Capacity Development.

SIDA. 2000. Working Paper No. 4. *Analysis of Needs for Capacity Development*

Sulaiman RV and Mittal N. 2016. *Capacity Needs of Extension and Advisory Services* (EAS) *in South Asia*. Policy Brief No 1. Agricultural Extension in South Asia. http:// www.aesanetwork.org/policy-brief-no-1-capacity-needs-of-extension-and-advisory-services- eas-in-south-asia/

Swanson BE and Rajalahti R. 2010. *Strengthening Agricultural Extension and Advisory Services.* A Guide for Facilitators.

TAP. 2013. *Capacity Development for Agricultural Innovation Systems - Key Concepts and Definitions*. Tropical Agricultural Platform

TAP. 2016. *Common Framework on Capacity Development for Agricultural Innovation Systems*. Guidance Note on Operationalization, Tropical Agricultural Platform

UNDP. 1998. *Capacity Assessment and Development in a Systems and Strategic Management Context*. Technical Advisory Paper No. 3. Management Development and Governance Division Bureau forDevelopment Policy, January 1998, United Nations Development Programme

UNDP. 1998. *CapacityAssessment and Development in a Systems and Strategic Management Context*. Technical Advisory UNU-MERIT, Netherlands.

UNDP. 2008. *Capacity Assessment Methodology. User's Guide*. Capacity Development Group. Bureaufor Development Policy.

UNDP. 2009. *Capacity Development: A UNDP Primer*, United Nations Development Programme WAC. 2013. *Assessing Capacity Needs and Strategy Development for Grassroots Rural Institutions: A Guide for Facilitators*. World Agroforestry Centre (WAC)

ICTs for Agricultural Extension and Advisory Services **EXT-506**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	**ICT- 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**	**1**
2.	**Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.**	**1**
3.	**E-Extension, overview on Global and national e-extension initiatives,**	**1**
4.	**Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.**	**1**
5.	**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)**	**1**
6.	**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.).**	**1**
7.	**Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, etc.**	**1**
8.	**Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CCRA, eduex, etc)**	**1**
9.	**E-Governance Systems; digital networks among extension personnel, Farmer Producers Organisations (FPOs)/ SHGs/ Farmers Groups.**	**1**
10.	**Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc.;**	**1**
	UNIT-II	
11.	**Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.**	**1**
12.	**Web standards, creating and writing for web portal, Development of mobile applications**	**2**
13.	**Developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.**	**1**
14.	Video conference, live streaming and webinars, types and functions of social media applications	**1**
15.	Guidelines for preparing social media content, engaging audience and data-analytics.	**1**
16.	Open technology computing facilities, System for data analytics/	**1**

	mining/ modelling/ Development of Agricultural simulations	
17.	Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies- Analysis; Internet of Things (IoTs), Drones,	**1**
18.	Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.	**1**
19.	Human Centered Learning/Ergonomics/ Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory	**1**
20.	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;	**2**
UNIT-III		
21.	Basic Principles of Multimedia Learning - Split-attention, Modality	**1**
22.	Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment	**1**
23.	Advanced principles - Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory	**1**
24.	Designing ICT gadgets based on human interaction principle	**1**
25.	Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity- centered design, systems design, and genius design	**1**
26.	Methods of interactive design- Usability testing methods.	**1**

Practicals

S. No.	Description
1.	Content and client engagement analysis
2.	Designing extension content for ICTs
3.	Creating and designing web portals, blogs, social media pages
4.	Developing digital videos
5.	Live streaming extension programmes and organising webinars
6.	Working with Farmers call centres
7.	Engaging with professional digital networks
8.	Writing with digital media

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 agriculture: connecting smallholders to knowledge, networks, and institutions. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/12613 16

Heike Baumüller. 2018. The little we know: An exploratory literature review on the utility of mobile phone enabled services for smallholder farmers. Journal of International Development. 30, 134–154.

Laurens K. 2016. NELK Module 6: Basic Knowledge Management and Extension, New Extensionist Learning Kit (NELK), Global Forum for Rural Advisory Services (GFRAS). http://www.g-fras.org/en/knowledge/new-extensionist-learning-kit-nelk.html# module-6-

Mayer RE. 2005. The Cambridge handbook of multimedia learning. New York: University of Cambridge.

MEAS & Access Agriculture 2013. A Guide to Producing Farmer-to-Farmer Training Videos. https://www.agrilinks.org/sites/default/files/resource/files/MEAS%20Guide%20to% 20Producing%20Farmer-to-Farmer%20Training%20 Videos%202013_04.pdf

Meera SN.2013. Extension, ICTs and Knowledge Management: The 10 difficult questions. Blog, Agricultural Extension in South Asia. http://www.aesanetwork.org/extension-icts-and-knowledge-management-the-10-difficult- questions/

Meera SN. 2017. Disruptive Technologies – Big Data and Internet of Things in Strengthening Extension & Advisory Services. Blog 68. Agricultural Extension in South Asia. http://www.aesanetwork.org/disruptive-technologies-big-data-and-internet-of-things-in-strengthening-extension-advisory-services/

Meera SN. 2018. A Treatise on Navigating Extension and Advisory Services through Digital Disruption. Blog 90. Agricultural Extension in South Asia. http://www.aesanetwork.org/a-treatise-on-navigating-extension-and-advisory-services-through-digital-disruption/

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Preece J, Rogers Y, & Preece, J. 2007. Interaction design: Beyond human-computer interaction.

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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/

Evaluation and Impact Assessment **EXT-507**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, analyse programme effectiveness	1
2.	Decision making, accountability, impact assessment	1
3.	Policy advocacy; Objectives, types, criteria and approaches of programme evaluation, Evaluation principles; the context of program evaluation in agricultural extension;	1
4.	Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.	1
5.	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)	1
6.	Approaches - utilization-focused evaluation & utilization-focused evaluation checklist, values engaged evaluation, empowerment evaluation, theory-driven evaluation	1
7.	Integration between theory and practice of evaluation: – evaluation forums, workshops, conferences and apprenticeship/ internship.	1
8.	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 and type of evaluation study	1
9.	(3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed)	1
10.	(6) Select data collection techniques (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques)	
11.	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).	1
12.	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	1
13.	Methods used for data collection and analysis, costs, recommendations and reports.	

	UNIT-II	
14.	**Programme Management Techniques - SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool**	**1**
15.	**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, Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event),**	**1**
16.	**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),**	**1**
17.	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.	**1**
18.	Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy, Advantages and Disadvantages of Bennett's hierarchy	**1**
19.	Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP)	**1**
20.	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,	**1**
21.	Means of Verification (mov) where information will be available on the OVIs, and Assumptions). Advantages and Disadvantages of LFA.	**1**
	UNIT-III	
22.	Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework:	**1**
23.	Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.	**1**
24.	Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioural indicators	**1**
25.	Socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators	**1**
26.	Impact assessment approaches – Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages	**1**
27.	Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental)	**1**
28.	Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal	**1**

	Rate of Return, Adoption Quotient, etc.). Qualitative and Participatory Impact Assessment Methods.	
29.	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.	**1**
30.	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,	**1**
31.	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?	**1**

Practicals

S. No.	Description
1.	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
2.	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.
3.	Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.
4.	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.
5.	Identify an on-going development programme and make-out 6 activities from the programme.
6.	Draw a Gantt chart for 12 months programme activities.
7.	Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.
8.	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.
9.	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.
10.	Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.

Suggested Reading:

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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-Champaign.

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Karthikeyan, C., Vijayaraghavan, K. and Lavanya, P. 2007. Formative evaluation of Kisan Call Centres. Tamil Nadu. Indian Journal of Extension Education, 43(1 &2): 20-25 (For LFA Example).

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Njuki J, Mapila M, Kaaria S and Magombo T. 2008. Using community indicators for evaluating research and development programmes: Experiences from Malawi. Development in Practice 18(4): 633–642.

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Sasidhar, P.V.K. and Suvedi, M. 2015. Integrated contract broiler farming: An evaluation case study in India. Urbana, IL: USAID-MEAS. www.meas.illinois.edu (For Bennett's Hierarchy Example).

Shadish, W. R. Jr., Cook, T. D., and Leviton, L. C. 1991. Chapter 2: Good theory for social program evaluation. Foundations of Program Evaluation: Theories of Practice (pp. 36-67). Newbury Park, CA: Sage.

Srinath, L.S. 1975. PERT and CPM Principles and Applications, East-West Press, New Delhi. Suvedi M, Heinze K and Ruonavaara D. 1999. How to Conduct Evaluation of Extension Programs. ANRECS Center for Evaluative Studies, Dept of ANR Education and Communication

Systems, Michigan State University Extension, East Lansing, MI, USA
https://msu.edu/~suvedi/Resources/Documents/4_1_Evaulation%20manual%202000.pdf
Suvedi M. 2011. Evaluation of agricultural extension and advisory services — A MEAS training

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Suvedi, M. and Kaplowitz, M.D. 2016. Process skills and competency tools – what every extension worker should know – Core Competency Handbook. Urbana, IL: USAID-MEAS.

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Wholey JS, Harty HP and Newcomer KE. 1994. Handbook of practical program evaluation. San Francisco, USA: Jossey-Bass Publishers.

Websites

Better Evaluation– www.betterevaluation.org

TAP– Tropical Agriculture Platform: Monitoring and Evaluation - www.tapipedia.org GFRAS– Global Forum for Rural Advisory Services http://www.g-fras.org/en/

AESA– Agricultural Extension in South Asia http://www.aesanetwork.org/ USAID– United States Agency for International Development: Evaluation

https://www.usaid.gov/evaluation https://education.illinois.edu/faculty/jennifer-greene

Managing Extension Organizations EXT-508

Credit Hrs.: 3(2+1)
Theory

S.No.	Topic	No. of Lecture
	Unit-I (A) **Management- An Over view**	
1.	**Management – Meaning, Concept, Nature and Importance**	**1**
2.	**Theories of Management – Classical, Neo-classical, Modern theories**	**1**
3.	**Management, Administration and Supervision – Meaning, Scope**	**1**
4.	**Approaches to Management – POSDCORB and Others**	**1**
5.	**Principles and Functions of Management**	**1**
6.	**Levels of Management**	**1**
7.	**Qualities and Skills of a Manager**	**1**
8.	**Interpersonal Relations in an Organization**	**1**
9.	**Reporting – Meaning, Methods and Importance**	**1**
10.	**Budgeting – Concept, Tools and Practices**	**1**
	Unit-I (B) **Extension Management in public, private sector and other sectors**	
11.	**POSDCORB in Public Sector Extension**	**1**
12.	**Department of Agriculture, ATMA and KVK – Structure & Functions**	**1**
13.	**SAUs and ICAR Institutes – Organizational Structure & Management**	**1**
14.	**Extension Management in Private Sector, Cooperatives, NGOs, FPOs**	**1**
15.	**Relations Between Different Units – Coordination Challenges in Private Sector, Cooperatives, NGOs, FPOs**	**1**
	Unit-II (A) **Concepts in Management**	
16.	**Decision Making Process – Concept, Types, Techniques and Steps**	**1**

17.	Human Resource Management – Manpower Planning, Recruitment, Selection	1
18.	Placement, Orientation, Training and Development	1
19.	Leadership – Concept, Characteristics, Functions, Approaches, Styles	1
20.	Authority, Responsibility, Delegation and Decentralization	1
21.	Line and Staff Relations in Extension Organizations	1
22.	Coordinating Pluralism in Extension Services and Interdepartmental Coordination & Convergence (KVK, ATMA, Line Departments)	1
23.	Challenges in Managing Public-Private Partnerships (PPPs)	1
24.	Performance Appraisal – Concept, Methods and Challenges	1
	Unit-II (B) Motivation and Communication	
25.	Work Motivation – Concept, Theories, Approaches, and Performance Link	1
26.	Team Building and Motivation in Extension Orgs; Organizational Communication – Concept, Process and Networks	1
27.	Types of Communication & Barriers to Communication	1
28.	Mentoring in Extension Organizations; Time Management, Team Work and Team-Building Strategies	1
29.	Modernization of Information Handling – ICTs in Extension Management	1
	Unit-III Supervision and Control	
30.	Supervision – Meaning, Responsibilities, Qualities and functions of supervision	1
31.	Essentials of effective supervision; Managerial Control – Nature, Process, Types, Techniques of Control, Observation,	1
32.	PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organizations.	1

Practicals

No.	Topic
1.	Simulated exercises on techniques of decision making
2.	Study the structure and function of agro-enterprises, Designing organizational structure/ organograms.
3.	Group activity on leadership development skills
4.	Simulated exercise to understand management processes
5.	Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management
6.	Practical exercises on PERT & CPM
7.	Group exercise on development of short term and long term plans for agroenterprises
8.	Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis

Suggested Reading

Bitzer V. 2016. *Incentives for enhanced performance of agricultural extension systems*, KIT Working Paper 2016-6, Royal Tropical Institute, Amsterdam https://www.kit.nl/wp-content/

uploads/ 2018/08/ Incentives-for-enhanced-performance-of-agricultural-extension-systems.pdf

Bitzer V, Wennik, B and de Steenhuijsen, B. 2016. *The governance of agricultural extension systems*, KIT Working Paper 2016-1Royal Tropical Institute, Amsterdam https://www.kit.nl/ wp-content/ uploads/2018/08/The-governance-of-agricultural-extension-systems.pdf

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GFRAS 2017. *Module 3: Agricultural Extension Programme Management*, The New Extensionist Learning Kit, Global Forum for Rural Advisory Services (GFRAS) http://www.g-fras.org/fr/component/phocadownload/category/70-new-extensionist-learning-kit- nelk.html?download=564: nelk-module-3-agricultural-extension-programme-management- textbook

Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand &Sons. New Delhi Hoffmann V, Gerster BM, Christnick A, Lemma M. 2009. *Rural Extension Volume 1-Chapter* MargrafPublishesrs, Kanalstr.

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Qamar, KM. 2005. *Modernizing National Agricultural Extension Systems: A Practical Guide for Policy-Makers of Developing Countries.* Food and Agriculture Organization of the United Nations http://www.fao.org/uploads/media/modernizing%20national.pdf

Swanson BE, Bentz RP, Sofranko AJ. 1997. *Improving Agricultural Extension. A Reference Manual.* Food and Agriculture Organization of the United Nations, Rome

Gender Mainstreaming EXT- 510

Credit Hrs.: 3(2+1)

Theory:

S.No.	Topic	No. of Lecture
	Unit I	
1.	**Historical perspective of gender: Feminism and emergence of gender as a concept**	**1**
2.	**Scope of gender studies in agriculture and rural development**	**1**
3.	**Agrarian importance of gender in national agriculture**	**1**
4.	**Agrarian importance of gender in global agriculture**	**1**
5.	**Key gender issues and challenges in agriculture**	**1**
6.	**Gender in agricultural value chain**	**1**
7.	**Global actions to address gender needs**	**1**
8.	**Concepts of gender: gender, sex, gender equality, equity, balance**	**1**
9.	**Gender blindness and gender relations**	**1**
10.	**Gender neutrality, gender bias and discrimination**	**1**
11.	**Gender rights, roles and responsibilities**	**1**
12.	**Gender budgeting: meaning and importance**	**1**
13.	**Gender needs: strategic needs and practical needs**	**1**
14.	**Gender divides: digital divide, access to resources and inputs divide**	**1**
15.	**Gender divides: gender mobility divide and Wage Divide**	**1**
	Unit 2	
16.	**Gender analysis: importance, usage and pre- requisites**	**1**
17.	**Techniques and tools for of Gender analysi**	**1**
18.	**Gender and technology: interaction of gender & technology**	**1**
19.	Gender neutral and gender sensitive technology	1
20.	Gender supportive assistance in technology adoption and agricultural research & extension	1
21.	Gender mainstreaming: importance in agriculture	1
22.	Extension strategies: gender and health	1
23.	Extension strategies: gender and nutrition	1
24.	Extension strategies: gender in agricultural value chains	1
25.	Extension strategies: gender and climate change adaptation	1
26.	Extension strategies: gender, globalization & liberalization	1
	Unit 3	
27.	Women empowerment: importance and national indices	1
28.	Women empowerment approaches: technological and organizational, political and financial	1
29.	Women empowerment approaches: social, legal and psychological	1
30.	Case studies from rural development programmes	1
31.	Global best practices, policies & frameworks for gender in agriculture	1
32.	Gender mainstreaming and special women focused programmes in agriculture and rural development.	1
33.	Entrepreneurship development for women: current status and support systems	1
34.	Women led enterprises	1

35.	Govt. policies and schemes for entrepreneurship development programme and process for women in agriculture.	1

Practicals

No.	Topic
1.	Visit to a village for understanding rural gender roles and responsibilities as groups, followed by class presentation by groups
2.	Exercise for capturing shifts in gender roles and responsibilities
3.	Conducting gender analysis in a village using gender analysis techniques
4.	Visit to agencies supporting women empowerment followed by report presentation.
5.	Visit to agencies supporting women empowerment followed by report presentation. Each student to visit a different organization such as State Rural Livelihood Mission, Women Development Corporation, Department of Agriculture, Important NGOs working for women empowerment
6.	Exercise for identification and prioritization of issues affecting/needs for women empowerment
7.	Interaction with a successful women entrepreneur/ SHG

Suggested Reading

AGRIPROFOCUS 2014. *Gender in value chains Practical toolkit to integrate a gender perspective in agricultural value chain development* https://agriprofocus.com/upload/ToolkitENGender_in_Value_ChainsJan2014compressed 1415203230.pdf

Christine J, Nafisa F and Taylor DS. 2014. *Gender and Inclusion Toolbox: Participatory Research in Climate Change and Agriculture.* Global Forum for Rural Advisory Services, Switzerland. http://www.gfras.org/en/component/phocadownload/category/17-gender.html?download =456:gender-and-inclusion-toolbox-participatory-research-in-climate-change-and-agriculture

Colverson KE. 2015. *Gender into Rural Advisory Services*. Global Forum for Rural Advisory Services, Switzerland. http://www.g-fras.org/en/good-practice-notes/integrating-gender-into-rural-advisory-services.html#SNote1

Entomology

Insect Morphology **ENT-501**
Credit Hours: 3 (2+1)
Theory

S. No.	Topics	No. of lectures
	Unit-I	
1.	**Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects**	**1**
2.	**Study of Insect body tagmata, sclerites and segmentation**	**1**
3.	**Study of Insect Head- Origin, structure and modification; tentorium and neck sclerites.**	**1**
4.	**Study of different types of insect mouthparts and their functioning**	**1**
5.	**Study of different types of insect antennae and their functioning**	**1**
6.	**Study of Insect Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax**	**1**
7.	**Study of Insect wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight**	**1**
8.	**Study of Insect legs: structure and modifications.**	**1**
	Unit-II	
9.	**Study of Insect Abdomen- Segmentation and its appendages; Insect Genitalia and their modifications.**	**2**
10.	**Study of embryonic and post-embryonic development in insects**	**1**
11.	**Study of organogenesis at pupal stage**	**1**
12.	Insect sense organs: Mechanoreceptors and Chemoreceptors; Study on chaetotaxy	1
13.	Insect sense organs: Photoreceptors	1
14.	Study on Insect Defense Mechanisms	1
15.	Morphological traits in relation to forensic entomology	1
	Unit-III	
18.	Types of immature stages in insect orders; morphology of egg, nymph/ larva and pupa	1
19.	Significance of insect immature stages for pest management strategies	1
20.	Identification of different immature stages of crop pests	1
21.	Identification of different immature stages of stored product insects	1
22.	Comparative study of life history strategies in hemimetabola and holometabola	1
23.	Study of insect immature stages as ecological and evolutionary adaptations	1

Practicals:

S. No.	Topics	No. of practical classes
1.	Preparation of permanent mounts of different body parts and their appendages of taxonomic importance- part I	1
2.	Preparation of permanent mounts of different body parts and their appendages of taxonomic importance- part II	1

3.	Dissection of insect genitalia of different orders	1
4.	Preparation of permanent mounts of male and female genitalia	1
5.	Collection of different types of immature stages of insects and their rearing and preservation	1
6.	Identification of immature stages of the order Diptera and its important families	1
7.	Identification of immature stages of the order Lepidoptera and its important families	1
8.	Identification of immature stages of the order Hymenoptera and its important families	1
9.	Identification of immature stages of the order Coleoptera and its important families	1

Suggested Reading

- Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge. Chu HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.
- Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi. Gillott C. 1995. *Entomology*, 2nd Ed. Plenum Press, New York, London.
- Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.
- Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.
- Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.
- Snodgross RE. 1993. *Principles of Insect Morphology.* Cornell Univ. Press, Ithaca.
- Tembhore DB. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.
- Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

Insect Anatomy and Physiology — ENT-502

Credit Hrs.: 3(2+1)

Theory:

S. No.	Topics	No. of lectures
	Unit-I	
1.	**Scope and importance of insect physiology; Overview of physiological systems in insects**	**1**
2.	**Physiology of integument (structure and functions) and chemistry of cuticle**	**2**
3.	**Biosynthesis of chitin (pathway and significance)**	**1**
4.	**Moulting process (ecdysis and apolysis) and its hormonal regulation**	**1**
5.	**Growth in insects and hormonal control of growth; Metamorphosis and Diapause in insects**	**1**
6.	**Pheromones: definition, types, secretion mechanisms, transmission, perception, and reception of pheromones**	**2**
	Unit-II	
7.	**Physiology and mechanism of digestion in insects**	**2**

8.	**Physiology and mechanism of circulatory system in insects**	**1**
9.	**Physiology and mechanism of respiratory system in insects**	**1**
10.	**Physiology and mechanism of excretory system in insects**	**1**
11.	Physiology and mechanism of male and female reproductive system in insects	2
12.	Types of reproduction in insects	1
	Unit-III	
13.	Study of exocrine and endocrine glands in insects and their function	1
14.	Physiology and mechanism of nerve impulse transmission in insects	2
15.	Introduction to Insect Nutrition and its Importance- Role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents	2
16.	Roles of Extra- and Intracellular Microorganisms in physiology	1
17.	Artificial Diets and Their Application	2

Practicals:

S. No.	Topics	No. of practical
1.	Latest analytical techniques for analysis of free amino acids in insect's haemolymph	1
2.	Examination and count of insect haemocytes in haemolymph	1
3.	Determination of chitin in insect cuticle	1
4.	Preparation of various artificial diets for different insects – Part I	1
5.	Preparation of various artificial diets for different insects – Part II	1
6.	Evaluation of consumption, utilization and digestion of natural and artificial diets – Part I	1
7.	Evaluation of consumption, utilization and digestion of natural and artificial diets – Part II	1
8.	Evaluation of consumption, utilization and digestion of natural and artificial diets – Part III	1

Suggested Reading:

- Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.
- Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.
- Kerkut GA and Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology.* Vols. I-XIII. Pergamon Press, New York.
- Patnaik BD. 2002. *Physiology of Insects*. Dominant Publishers, New Delhi.
- Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology.* 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman and Hall, New York.
- Simpson SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London,
- Wigglesworth VB. 1984. *Insect Physiology.* 8th Ed. Chapman and Hall, New York.

Insect Taxonomy **ENT-503**
Credit Hours: 3 (1+2)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1.	**History of Insect classification: Pre-Linnaean, Linnaean and Post-Linnaean Taxonomy**	**1**
2.	**Principles of systematics and its importance; Purpose and methods of insect identification; Character matrix and its use in systematics; Taxonomic keys: types and applications**	**1**
3.	**Descriptions and Characters in Taxonomy: Subjects of descriptions; Characters and their nature; Analogy v/s homology; Parallel v/s convergent evolution**	**1**
4.	**Variation and Taxa Types: Intraspecific variation in characters; Polythetic v/s polymorphic taxa; Sexual dimorphism in insects**	**1**
5.	**Brief evolutionary history of insects; Introduction to insect phylogeny and Classification of Superclass Hexapoda- Classes: Ellipura (Collembola, Protura), Diplura, Insecta& Orders contained.**	**1**
6.	**Codes of Nomenclature: International Code of Zoological Nomenclature (ICZN)- principles and applications; Phylocode- brief explanation and uses**	**1**
	Unit II	
7.	**Process of speciation, Interbreeding and allopatric species. Molecular Systematics: DNA barcoding, Karyological approaches, Biochemical approaches. Insect labeling protocols and procedures.**	**1**
8.	**Study on hexapods orders Collembola, Protura, Diplura: Distinguishing characters, general biology, habits and habitats, economically important families**	**1**
9.	**Study on Class Insecta: Subclass: Apterygota- Orders: Archaeognatha, Thysanura.; Subclass: Pterygota- Division Palaeoptera- Orders: Odonata and Ephemeroptera.**	**1**
10.	Study on Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera),	2
	Unit III	
11.	Study on Division: Neoptera: Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.	1
12.	Study on Division: Neoptera: Subdivision: Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera,	2
13.	Study on Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera	2
14.	Study on Order Hymenoptera	1

Practicals:

S. No.	Topics	No. of practical classes
1.	Field visits to collect insects of different orders- I	1
2.	Field visits to collect insects of different orders - II	1
3.	Identification of different insect orders by using taxonomic keys	1
4.	Study of order Odonata and identification of its important families	1
5.	Study of order Orthoptera and identification of its important families	1
6.	Study of order Blattodea and identification of its important families	1
7.	Study of order Mantodea and identification of its important families	1
8.	Study of order Isoptera and identification of its important families	1
9.	Study of order Hemiptera and identification of its important families	2
10.	Study of order Thysanoptera and identification of its important families	1
11.	Study of order Phthiraptera and identification of its important families	1
12.	Study of order Neuroptera and identification of its important families	1
13.	Study of order Coleoptera and identification of its important families	2
14.	Study of order Diptera and identification of its important families	2
15.	Study of order Lepidoptera and identification of its important families	2
16.	Study of order Hymenoptera and identification of its important families	2

Suggested Reading

- Triplehorn CA and Johnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.
- 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.
- 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.
- Ross HH.1974. Biological Systematics. Addison Wesley Publ. Company.

Biological Control of Insect Pests and Weeds — ENT-505

Credit Hours: 3 (2+1)

Theory

S. No.	Topics	No. of lectures
	Unit-I	
1.	**History, principles and scope of biological control**	**1**
2.	**Study of important groups of parasitoids, predators and pathogens**	**1**
3.	**Principles of classical biological control- Importation, augmentation and conservation**	**1**
4.	**History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes**	**2**
5.	**Beneficial Role of insect pathogenic nematodes and their mode of action.**	**1**
6.	**Beneficial Role of insect pathogenic viruses and their mode of action.**	**1**

Unit-II		
7	**Beneficial Role of insect pathogenic bacteria and their mode of action.**	**2**
8	**Beneficial Role of insect pathogenic fungi and protozoa and their mode of action.**	**2**
9	Epizootiology, symptomatology and etiology of diseases caused by the different insect pathogens and the factors controlling them	1
10	Biological control of weeds using insects	1
11	Defense mechanisms in insects against pathogens	1
Unit-III		
12	Mass production of quality bio-control agents- techniques, formulations, economics, field release/application and evaluation	2
13	Development of insectaries and their maintenance	1
14	Successful biological control projects, analysis, trends and future possibilities of biological control	2
15	Importation of natural enemies- Quarantine regulations; Biotechnology in biological control programme	1
16	Usage of Semiochemicals in biological control programme	1

Practicals:

S. No.	Topics	No. of practical classes
1.	Field collection of parasitoids and predators of insect pests – Part I	1
2.	Field collection of parasitoids and predators of insect pests – Part II	1
3	Identification of common natural enemies of crop pests (parasitoids, predators, microbes)	1
4.	Identification of common weed killer insects	1
5	Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids	1
6.	Visits to bio-control laboratories to learn rearing and mass production of common predators, microbes and their laboratory hosts	1
7.	Visits to bio-control laboratories to learn rearing and mass production of phytophagous natural enemies of weeds	1
8.	Hands-on training in culturing and identification of common insect pathogens.	1
9.	Quality control and registration standards for biocontrol agents	1

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.

Toxicology of Insecticides **ENT-506**
Credit Hrs.: 3(2+1)
Theory

S. No.	Topics	No. of lectures
	Unit-I	
1.	**Definition and scope of insecticide toxicology. History of chemical control of insects**	**1**
2.	**Status of Pesticide use and pesticide industry in India.**	**1**
3.	**Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature**	**1**
4.	**categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general**	**1**
5.	**structure and mode of action of organochlorines**	**1**
6.	**structure and mode of action of Organophosphates**	**1**
7.	**structure and mode of action of Carbamates and Pyrethroids**	**1**
8.	**structure and mode of action of Neonicotinoids and tertiary amines**	**1**
	Unit-II	
9.	**Structure and mode of action of Oxadiazines, Phenyl pyrazoles and Spinosyns**	**1**
10.	**Structure and mode of action of Diamides and other new insecticide molecules**	**1**
11.	**Structure and mode of action of Insect growth regulators**	**1**
12.	**Structure and mode of action of microbial insecticides**	**1**
13.	**Structure and mode of action of botanicals**	**1**
14.	Study of Nanopesticides. Drawbacks of insecticide abuse	1
15.	Principles of toxicology and evaluation of insecticide toxicity	1
16.	Joint action of insecticides- synergism, potentiation and antagonism.	1
17.	Insecticide compatibility, selectivity and phytotoxicity. Factors affecting toxicity of insecticides.	1
	Unit-III	
18.	Bioassay definition, objectives, criteria, factors, problems and solutions	1
19.	Insecticide metabolism and insect-pest resistance to insecticides. Insect-pest resistance mechanisms and types of resistance	2
20.	Insecticide resistance management and pest resurgence	1
21.	Insecticide residues, their significance and environmental implications	1
22.	Procedures of insecticide residue analysis	1
23.	Insecticide Act, registration procedures, label claim, and quality control of insecticides	1

24.	Safe usage of insecticides	1
25.	Diagnosis and treatment of insecticide poisoning	1

Practicals:

S. No.	Topics	No. of practical classes
1.	Insecticide formulations and mixtures	1
2.	Laboratory and field evaluation of bio-efficacy of insecticides	1
3.	Bioassay techniques	1
4.	Probit analysis	1
5.	Evaluation of insecticide toxicity	1
6.	Toxicity to beneficial insects	1
7.	Pesticide appliances	1
8.	Working out doses and concentrations of pesticides	1
9.	Procedures of residue analysis	1

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.MathewsGA.2002.PesticideApplicationMethods.4thEd.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.

Concepts of Integrated Pest Management — ENT-508

Credit Hours: 2 (2+0)

Theory

S. No.	Topics	No. of lectures
	Unit-I	
1	**History, origin, definition and evolution of various terminologies related to IPM**	**1**

2	**Concept and philosophy of IPM, ecological principles**	**1**
3	**Characterization of agro-ecosystems; sampling methods and factors affecting sampling**	**1**
4	**Crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses**	**1**
5	**Concept of Economic threshold level (ETL) and Economic injury level (EIL) and their computation**	**1**
6	**Tools of pest management and their integration- cultural, physical, mechanical methods**	**1**
7	**Tools of pest management and their integration- biological and chemical methods**	**1**
8	**Tools of pest management and their integration- legislative and quarantine regulations**	**1**
	Unit-II	
9	**Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects**	**1**
10	**Importance of Host plant resistance, principles, classification, components, types and mechanisms of host plant resistance**	**1**
11	**Semiochemicals, biotechnological and bio-rational approaches in IPM**	**1**
12	**Indigenous Technical Knowledges (ITKs) in IPM**	**1**
13	Components of ecological engineering with successful examples	1
14	Crop modeling; designing and implementing IPM system	1
15	Screening techniques and breeding for insect resistance in cropplants	1
16	Exploitation of wild plant species, gene transfer, successful examples of resistant crop varieties in India and world	1
17	Synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons	1
	Unit-III	
18	Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys	2
19	Area-wide IPM and IPM for organic farming	1
20	Pest risk analysis (PRA); pesticide risk analysis; cost- benefit ratios and partial budgeting	1
21	Political, social and legal implications of IPM	1
22	Case studies of successful IPM programmes	1
23	Study of the national and international crop protection organizations and their functions	1
24	Study of Insecticide regulatory bodies in India	1

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.

Pests of Field Crops **ENT-509**
Credit Hours: 3 (2+1)

Theory

S. No.	Topics	No. of lectures
	Unit-I	
1.	**Economic importance of insect pests in field crops**	**1**
2.	**Impact of climate change on Insect Pest Dynamics**	**1**
3.	**Study on major insect pests of Rice and their management- Yellow stem borer, brown planthopper (BPH), gallmidge, green leafhopper, hispa, leaf folder, earhead bug, grasshoppers, climbing cutworm, case worm**	**3**
4.	**Study on major insect pests of Sorghum and other Millets- Sorghum shoot fly, spotted stem borer, fall armyworm (FAW), sorghum midge, ear head bug, shoot bug, aphids, Ragi/pink stem borer , ragi cutworm, ragi root aphid, army worm, white grubs, flea beetles**	**2**
5.	**Study on major insect pests of Wheat and their management - Termites, armyworms, ragi pink borer, ghujia weevil, aphids; Major insect pests of Maize and their management - Spotted stem borer, fall armyworm (FAW), pink stem borer, shoot fly**	**2**
	Unit-II	
6.	**Study on major insect pests of pulses (Redgram, Mungbean, Chickpea, and Black gram)- Gram pod borer, plume moth, redgram pod fly, spotted pod borer, aphids, pod bug, whiteflies, leafhopper, green stink bug, blue butterflies, armyworm, cutworm, termites**	**2**
7.	**Study on major insect pests of Kharif oilseeds (Soybean, Groundnut, Sesamum, and Sunflower)- Girdle beetle, stem fly, tobacco caterpillar, whitefly,white grub, groundnut leaf miner, red hairy caterpillar, leafhopper, thrips, aphid, Sesamum leaf webber and capsule borer, gall fly, sphinx caterpillar, head borer, Bihar hairy caterpiller**	**2**
8.	Study on major insect pests of Rabi oilseed crops (Rapeseed-mustard and Safflower) and their management - Mustard aphids, mustard saw fly, painted bug, leaf miner, Safflower aphid, Safflower caterpillar	2
9.	Study on major insect pests of fiber crops (Cotton and Jute) and their management - American bollworm, pink bollworm, spiny/spotted bollworm, tobacco caterpillar, leafhopper, whiteflies, aphid, thrips, red cotton bug, dusky cotton bug, leaf roller, stem weevil, mealybug, flower bud maggot, Jute semilooper, Jute mealybug, Jute stem girdler, Jute stem weevil	2

Unit-III		
10.	Study on major insect pests of Sugarcane and their management- Early shoot borer, internodal borer, top shoot borer, scales, leafhoppers, white grub, mealybugs, termites, whiteflies, woolly aphid	2
11.	Study on major insect pests of tobacco and their management – Tobacco leaf eating caterpillar, white fly, stem borer, ground beetle, tobacco bud worm, tobacco aphid, cigarette beetle; Major insect pests of forage crops and their management - alfalfa weevil, aphids, jassids, armyworms	1
12.	Polyphagous insect pests of crops: Locusts and grasshoppers, termites, white grubs, hairy caterpillars, cutworms	2
13.	Insect vectors of plant diseases	1
14.	Non-insect pests of crops: mites, snails, and slugs	2
15.	Non-insect pests of crops: birds and rodents	1

Practicals:

S. No.	Topics	No. of practical classes
1.	Field visits, collection and identification of important pests and their natural enemies – Part I	1
2.	Field visits, collection and identification of important pests and their natural enemies – Part II	1
3.	Field visits, collection and identification of important pests and their natural enemies – Part III	1
4.	Detection and estimation of pests infestation and losses in oilseed crop	1
5.	Detection and estimation of pests infestation and losses in pulse crop	1
6.	Detection and estimation of pests infestation and losses in cereal/millets crop	1
7.	Study of life history of important insect pests of field crops- Part I	1
8.	Study of life history of important insect pests of field crops- Part II	1
9.	Study of life history of important insect pests of field crops- Part III	1

Suggested Reading

- David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology.* Popular Book Depot, Chennai.
- Dhaliwal GS, Singh R and Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publishers, New Delhi.
- Dunston AP. 2007. The Insects: Beneficial and Harmful Aspects. Kalyani Publishers, New Delhi Evans JW. 2005. Insect Pests and their Control. Asiatic Publ., New Delhi.
- Nair MRGK. 1986. Insect and Mites of Crops in India. ICAR, New Delhi. Prakash I and Mathur RP. 1987. Management of Rodent Pests. ICAR, New Delhi.
- Saxena RC and Srivastava RC. 2007. Entomology at a Glance. Agrotech Publ. Academy, Udaipur.

Techniques in Plant Protection **ENT-515**
Credit Hours: 1 (0+1)
Practical

S. No.	Topics	No. of lectures
1.	Plant protection equipments : Principles, operation, maintenance, selection, and safe application of pesticides	1
2.	Methods of pesticide application: Seed dressing, soaking, root-dip treatment, dusting, spraying, chemigation (application through irrigation water)	1
3.	Application of drones and precision technologies in plant protection	1
4.	Release of bio-control agents	1
5.	Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers	1
6.	Use of microscopy – Light microscopy, transmission and scanning electron microscopy	1
7.	Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE	1
8.	Use of tissue culture techniques in plant protection	1
9.	Computerapplicationforpredicting/forecastingpestattackandidentification	1
10.	Application of AI in pest management	1

Suggested Reading

- Alford DV. 1999. A Textbook of Agricultural Entomology. Blackwell Science, London.
- Crampton JM and Eggleston P. 1992. Insect Molecular Science. Academic Press, London.
- Matthews, G. A. (2014). Pesticide Application Methods (4th Ed.). Wiley-Blackwell.
- Wilson, K. & Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology (8th Ed.). Cambridge University Press.
- Hayat, M. A. (2000). Principles and Techniques of Electron Microscopy: Biological Applications. Cambridge University Press

Genetics and Plant Breeding

Principles of Genetics **GPB-501**
Credit Hrs.: 3(2+1)
Theory

S. No.	Topics	No. of Lecture
	Unit-I	
1.	**Beginning of Genetics, Cell Structure and Cell Division, Early Concepts of Inheritance**	**1**
2.	**Mendel's Law, Discussion on Mendel's paper, Chromosomal Theory of Inheritance**	**1**
3.	**Chromosomal Aberration (Structural & Numerical Changes), GISH & FISH**	**2**
4.	**Multiple Alleles, Gene Interaction**	**1**
5.	**Sex determination, Differentiation and Sex Linkage, Sex Influenced and Sex-Limited Traits**	**1**
6.	**Linkage detection and estimation**	**1**
7.	**Recombination and genetic mapping in eukaryotes**	**1**
8.	**Somatic Cell Genetics, Extra Chromosomal Inheritance**	**1**
9.	**Mendelian Population, Random Mating Population**	**1**
10.	**Frequencies of genes and genotypes, Causes of change: Hardy Weinberg Equilibrium**	**1**
11.	**Nature, structure and replication of the genetic material**	**1**
	Unit-II	
12.	**Organization of DNA in chromosomes**	**1**
13.	**Genetic Code & Protein biosynthesis**	**1**
14.	**Gene fine structure analysis**	**1**
15.	**Allelic Complementation, Split Genes, Transposable elements, Overlapping genes, Pseudogenes, Oncogenes**	**1**
16.	**Gene families and clusters**	**1**
17.	**Regulation of gene activity in prokaryotes and eukaryotes**	**1**
18.	Molecular mechanism of mutation, repair and suppression	2
19.	Bacterial Plasmids, Insertion (IS) and transposable (Tn) elements	1
20.	Molecular Chaperons and Gene expression	1
21.	Gene regulation in eukaryotes	1
22.	RNA editing	1
	Unit-III	
23.	Gene isolation, synthesis and cloning, Genomic and cDNA libraries	1
24.	PCR based cloning, Positional cloning, Nucleic acid hybridization and immunochemical detection	1
25.	DNA sequencing, DNA restriction and modification	1
26.	Anti-sense RNA and ribozymes, Micro-mRNAs	1

27.	Genomics and Proteomics, Metagenomics	1
28.	Methods of studying polymorphism at biochemical and DNA level	2
29.	Transgenic bacteria and bioethics	**1**
30.	Gene Silencing	1
31.	Genetics of Mitochondria and Chloroplasts	1
32.	Concepts of Eugenics, Epigenetics and Behavioural Genetics	1
33.	Genetic Disorders	1

Practical

S.No.	Topic
1.	Exercises based on probability, monohybrid and dihybrid crosses
2.	Exercises based on chi-square test and epistasis
3.	Demonstration of genetic principles using laboratory organisms (linkage, multiple allelism etc.)
4.	Chromosome mapping using three three-point test cross
5.	Chromosomal Aberration, GISH and FISH Techniques
6.	Study on Tetrad analysis
7.	Induction and detection of mutations through genetic tests (Physical Agents)
8.	Induction and detection of mutations through genetic tests (Chemical Agents)
9.	DNA extraction
10.	PCR amplification
11.	Electrophoresis – basic principles and running of amplified DNA
12.	Extraction of proteins and isozymes
13.	Use of *Agrobacterium-mediated* method of genetic transformation
14.	Biolistic Gun Approach of genetic transformation
15.	Detection of transgenes in the exposed plant material
16.	Visit to transgenic glasshouse and learning the practical considerations related to transgenes

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.

Principles of Plant Breeding **GPB-502**
Credit Hrs.: 3(2+1)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Early Plant Breeding history and accomplishments through plant breeding**	1
2.	**Objectives of plant breeding and Patterns of crop evolution in crop plants**	1
3.	**Centre of Origin, Agro-biodiversity and its significance.**	1
4.	**Pre-Breeding, Plant introduction, Plant genetic resources and their role in plant breeding**	1
5.	**Genetic basis of self and cross pollinated crops, Mating systems and response to selection**	1
6.	**Nature of variability, Components of variation, Heritability and Genetic advance, General and specific combining ability**	1
7.	**Genotype x environment interaction; Types of Gene actions and implications in plant breeding**	1
8.	**Overview of breeding methods for self-pollinated, cross-pollinated and vegetative propagated crops**	1
9.	**Mass selection, Pure line theory and pure line breeding method, Progeny test and selection schemes**	1
10.	**Pedigree breeding method; Bulk breeding and Single seed descent (SSD) method**	1
11.	**Back cross breeding method; Multiline breeding method and Transgressive breeding**	1
12.	**Population breeding in self-pollinated crops with special reference to diallel selective mating**	1
	Unit-II	
13.	**Breeding methods for cross pollinated crops- Population breeding: mass selection method and ear to row methods**	1
14.	**S_1 and S_2 progeny testing, progeny selection schemes**	1
15.	**Recurrent selection schemes for intra and inter-population improvement**	1
16.	**Development of Synthetics and composites**	1
17.	**Self-incompatibility and their commercial exploitation**	1
18.	**Apomixis in crop plants and its use in plant breeding**	1
19.	Male sterility in crop plants and their commercial exploitation	1
20.	Hybrid Breeding: genetical and physiological basis of heterosis and inbreeding	1
21.	Production of inbreds and approaches for inbreds improvement, predicting hybrid performance	1
22.	Seed production of hybrids and their parent varieties/inbreds	1
23.	Breeding methods in asexually/clonally propagated crops and clonal selection	1

24.	Mutation breeding	1
	Unit-III	
25.	Breeding for abiotic stresses	1
26.	Breeding for biotic stresses	1
27.	Breeding for Quality Traits	1
28.	Concept of plant ideotype and its role in crop improvement	1
29.	Concept of Marker Assisted Selection	1
30.	Wide Hybridization and its use in crop improvement	1
31.	Fertilization barriers in crop plants at pre-and post-fertilisation levels; In-vitro techniques to overcome the fertilization barriers in crops	1
32.	Concept of Polyploidy	1
33.	Haploidy and Double haploid breeding	1
34.	Cultivar development: testing, release and notification	1
35.	Maintenance breeding and Participatory Plant Breeding	1
36.	Plant breeder's rights and regulations for plant variety protection and farmers rights	1

Practical

S.No.	Topic
1.	Plant breeder's kit and identification of the mode of pollination in crops
2.	Study of Floral biology in self and cross-pollinated crop
3.	Techniques of selfing and crossing
4.	To study the effect of selfing
5.	Evaluation of Breeding Material
6.	Estimation of Analysis of Variance (ANOVA)
7.	Estimation of Heritability and Genetic Advance
8.	Study of various selection methods in segregating populations
9.	Study on estimation of heterosis and inbreeding depression
10.	Prediction of the performance of double cross
11.	Techniques to induce polyploidy
12.	Techniques to induce mutation
13.	Pollen viability and germination test
14.	Techniques of hybrid seed production
15.	Maintenance breeding
16.	Concepts of field layout, crossing block and maintenance of experimental records

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.

Fundamentals of Quantitative Genetics GPB-503

Credit Hrs.: 3(2+1)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Introduction and historical background of quantitative genetics**	1
2.	**Multiple factor hypothesis, Qualitative and quantitative characters**	1
3.	**Analysis of continuous variation mean, range, SD, CV**	1
4.	**Components of variation- Phenotypic, Genotypic; Nature of gene action- additive, dominance and epistatic, linkage effect**	1
5.	**Principles of analysis of variance and linear model**	1
6.	**Expected variance components; Random and fixed effect model**	1
7.	**Comparison of means and variances for significance**	1
8.	**Designs for plant breeding experiments- principles and applications**	1
9.	**Variability parameters, concept of selection, simultaneous selection modes and selection of parents**	1
10.	**MANOVA**	1
11.	**Association analysis- Genotypic and phenotypic correlation**	1
	Unit-II	
12.	**Path analysis**	1
13.	**Discriminant function**	1
14.	**Principal component analysis**	1
15.	**Genetic divergence analysis- Metroglyph and D^2**	1
16.	**Generation mean analysis**	1
17.	**Parent progeny regression analysis**	1
18.	**Mating designs- classification, Diallel Analysis**	2
19.	Partial diallel Analysis	1
20.	Line x tester analysis	1
21.	NCDs	1
22.	TTC	1
23.	Concepts of combining ability and gene action	1

24.	G x E interaction-Adaptability and stability	1
	Unit-III	
25.	Methods and models for stability analysis	1
26.	Basic models- principles and interpretation, Bi-plot analysis	2
24.	QTL mapping; Strategies for QTL mapping; Desired populations for QTL mapping	2
28.	Statistical methods in QTL mapping; QTL mapping in Genetic analysis	1
29.	Markers, Marker assisted selection (MAS) factors influencing the MAS	2
30.	Factors influencing the MAS	1
31.	Selection based on marker; Simultaneous selection based on marker and phenotype; Factors influencing MAS	2

Practical

S.No.	Topic
1.	Analysis and interpretation of variability parameters
2.	Analysis and interpretation of Index score and Metroglyph
3.	Clustering and interpretation of D2 analysis.
4.	Genotypic and phenotypic correlation analysis and interpretation
5.	Path coefficient analysis and interpretation
6.	Estimation of different types of heterosis, inbreeding depression and interpretation
7.	A, B and C Scaling test
8.	L x T analysis and interpretation, QTL analysis
9.	Use of computer packages
10.	Diallel analysis
11.	GxE interaction
12.	Stability analysis
13.	Association analysis - phenotypic and genotypic correlations
14.	Path analysis and Parent - progeny regression analysis
15.	Discriminant function and principal component analysis
16.	Selection indices - selection of parents; Simultaneous selection models- concepts of selection

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.

Varietal Development and Maintenance Breeding **GPB-504**
Credit Hrs.: 2(1+1)
Theory

S.No.	Topic	Lecture
	Unit-I	
1.	**Variety development systems and maintenance – importance and scope**	1
2.	**Definitions: variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population**	1
3.	**Variety testing, release and notification systems in India**	1
4.	**Variety release and notification norms in international systems**	1
5.	**DUS testing – concept, importance and procedures**	1
6.	**DUS descriptors for major field crops**	1
	Unit-II	
7.	**Genetic purity concept and its role in maintenance breeding; Factors responsible for genetic deterioration of varieties**	1
8.	**Safeguards during seed production to maintain varietal purity**	1
9.	**Maintenance of varieties in self-pollinated crops**	1
10.	Maintenance of varieties in cross-pollinated crops	1
11.	Isolation distance for varietal and hybrid seed production	1
12.	Principles of seed production and methods of Nucleus and breeder seed production	1
	Unit-III	
13.	Generation system of seed multiplication – nucleus, breeder, foundation, and certified seed	1
14.	Quality seed production technology in cereals and millets (wheat, barley, rice, pearl millet, sorghum, maize, ragi)	1
15.	Quality seed production in pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil etc.)	1
16.	Quality seed production in oil seed (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard etc.)	1
17.	Quality seed production in fibres (cotton, jute) and forages (forage sorghum, teosinte, oats, berseem, lucerne)	1
18.	Seed certification procedures; Seed laws, Acts, and Plant Variety Protection regulations (PPV&FR) in India and international systems	1

Practical

S.No.	Topic
1.	Identification of suitable areas/locations for seed production.
2.	Ear-to-row method and nucleus seed production in self-pollinated crops.
3.	Study of the main characteristics of released and notified varieties.
4.	Study of the main characteristics of released and notified hybrids and parental lines.
5.	Study of PGMS (Photoperiod-sensitive Genetic Male Sterility) and TGMS (Thermosensitive Genetic Male Sterility) systems.
6.	Identification of important weeds and objectionable weeds in seed production plots.
7.	Determination of isolation distance for different crops.
8.	Determination of planting ratios in different crops.
9.	Seed production techniques of varieties in cereals and millets.
10.	Seed production techniques of varieties in pulses.
11.	Seed production techniques of varieties in oilseeds.
12.	Hybrid seed production technology of important crops
13.	Study of DUS testing procedures in major crops.
14.	Recording DUS descriptors in cereals, pulses and oilseeds.
15.	Preparation of variety release proposal formats in different crops.

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

Molecular Breeding and Bioinformatics GPB-506

Credit Hrs.: 3(2+1)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Genotyping; Biochemical and Molecular markers**	1
2.	**Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.)**	1
3.	**Functional markers**	1
4.	**Mapping populations (F2s, back crosses, RILs, NILs and DH);**	1
5.	**Molecular mapping and tagging of agronomically important traits;**	1
6.	**Statistical tools in marker analysis**	1
7.	**Allele mining**	1
8.	**Marker-assisted selection for qualitative traits**	1
9.	**Marker-assisted selection for quantitative traits**	1

10.	**QTLs analysis in crop plants**	1
11.	**Marker-assisted backcross breeding for rapid introgression**	1
	Unit-II	
12.	**Genomics- assisted breeding;**	1
13.	**Generation of EDVs; Gene pyramiding**	1
14.	**Introduction to Comparative Genomics**	1
15.	**Large scale genome sequencing strategies**	1
16.	**Human genome project; Arabidopsis genome project; Rice genome project**	1
17.	**Comparative genomics tools**	1
18.	**Introduction to proteomics; 2D gel electrophoresis**	1
19.	Chromatography & sequencing by Edman degradation & mass spectrometry;	1
20.	Endopeptidases; Nanotechnology and its applications in crop improvement.	1
21.	Recombinant DNA technology, transgenes	1
22.	Method of transformation, selectable markers and clean transformation techniques	1
23.	Vector-mediated gene transfer	1
24.	Physical methods of gene transfer	1
	Unit-III	
25.	Production of transgenic plants and commercial releases in various field crops: cotton, wheat, maize	1
26.	Production of transgenic plants and commercial releases in various field crops: rice, soybean	1
27.	Production of transgenic plants and commercial releases in various field crops: oilseeds, sugarcane etc.	1
28.	Biotechnology applications in male sterility/hybrid breeding, molecular farming	1
29.	Application of Tissue culture in molecular breeding;	1
30.	MOs and related issues (risk and regulations)	1
31.	GMO, International regulations	1
32.	Biosafety issues of GMOs, Regulatory procedures in major countries including India, ethical, legal and social issues	2
33.	Intellectual property rights	1
34.	Introduction to bioinformatics: bioinformatics tools	1
35.	Biological data bases (primary & secondary), implications in crop improvement	1

Practical

S.No.	Topic
1.	Requirements for plant tissue culture laboratory & Techniques in plant tissue culture
2.	Media components and media preparation

3.	Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations
4.	Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration
5.	Hardening of regenerated plants; Establishing a greenhouse and hardening procedures
6.	Visit to commercial micropropagation unit
7.	Transformation using Agrobacterium strains
8.	Study of GUS assay in transformed cells / tissues
9.	DNA isolation, DNA purity and quantification tests
10.	Study of Gel electrophoresis of proteins and isozymes
11.	Study of Gel electrophoresis of PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship
12.	Study on Construction of genetic linkage maps using computer software.
13.	Study of NCBI Genomic Resources, GBFF, Swiss Prot, Blast n / Blast p
14.	Study of Gene Prediction Tool, Expasy Resources, PUBMED & PMC, OMIM & OMIA, ORF finder
15.	Comparative Genomic Resources: - Map Viewer (UCSC Browser & Ensembl)
16.	To study Primer designing

Suggested Reading

- Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*.John Wiley and Sons.
- Brown TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition
- Chawala HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd.
- Chopra VL and 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 and Messing JW. 1988. *An Introduction to Recombinant DNA Technology Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.
- Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.
- Lewin B. 2017. *Genes XII*. Jones & Bartlett learning, 2017.
- Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology.* CRC Press.
- Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi. Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

Mutagenesis and Mutation Breeding **GPB-508**
Credit Hrs.: 3(2+1)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Mutation and its history, nature and classification of mutations, spontaneous and induced mutations**	1
2.	**Micro and macro mutations, pre and post adaptive mutations**	1
3.	**Detection of mutations**	1
4.	**Paramutations in crops plants**	1
5.	**Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations**	1
6.	**Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships**	2
7.	**Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects**	2
8.	**Dosimetry -Objects and methods of treatment**	1
9.	**Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects**	1
	Unit-II	
10.	**Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume**	2
11.	**Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action**	2
12.	**Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments**	1
13.	Other causes of mutation –direct and indirect action, comparative evaluation of physical and chemical mutagens	2
14.	Observing mutagen effects in M1 generation: lethality, sterility, chimeras etc.	1
15.	Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations	1
16.	Mutations in traits with continuous variation	1
17.	Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage etc.	1
	Unit-III	
18.	Individual plant-based mutation analysis and working out effectiveness and efficiency in M3 generation	1

19.	Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies	1
20.	Use of mutagens in creating oligogenic and polygenic variations – Case studies	1
21.	In vitro mutagenesis – Callus and pollen irradiation;	1
22.	Handling of segregating M2 generations and selection procedures	1
23.	Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement etc.) in different crops	1
24.	Procedures for micromutations breeding/polygenic mutations	1
25.	Achievements of mutation breeding varieties released across the world, problems associated with mutation breeding.	1
26.	Use of mutagens in genomics, allele mining, TILLING	2

Practical

S.No.	Topic
1.	Laboratory safety protocols in handling mutagens
2.	Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens.
3.	Learning about Radioactivity- Production source and isotopes at BRIT, Trombay; Learning about the gamma chamber
4.	Radiation hazards: Monitoring – safety regulations and safe transportation of Radioisotopes
5.	Determination of dose/concentration of physical and chemical mutagens and LD_{50} (Lethal Dose for 50% population) for mutagenic treatment in different crops.
6.	Learning about safe disposal of radioisotopes; Hazards due to chemical mutagens
7.	Treating the plant propagules with different doses of physical and chemical mutagens; Procedures in combined mutagenic treatments.
8.	Raising the crop for observation; Mutagenic effectiveness and efficiency,
9.	Raising M_1 generation (treated material) and recording different parameters
10.	Growing M_2 generation and recording different parameters
11.	Procedure for the detection of mutations for polygenic traits in M2 and M3 generations.
12.	Study on mutation breeding in cereals & pulses - achievements made and an analysis
13.	Study on mutation breeding in cotton & oilseeds; achievements and opportunities
14.	Study on mutation breeding in forage & vegetatively propagated crops
15.	Identification of chlorophyll mutations (albino, xantha, viridis, chlorina, etc.)
16.	Documentation of mutants with photographs, herbarium sheets, or field records.

Suggested Reading

- Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.
- Chadwick KH and Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer- Verlag.
- 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. Strick Berger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall. www.barc.gov.in

Seed Production and Certification **GPB-510**
Credit Hrs.: 2(1+1)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Importance of seed as a basic input in agriculture; Concept and importance of seed quality**	1
2.	**Generation system of Seed multiplication, Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, seed renewal period, seed demand and supply**	2
3.	**Factors influencing seed production: Physical purity and genetic purity. Factors responsible for varietal and genetic deterioration in seed production**	1
4.	**Nucleus seed production and maintenance; Maintenance of parental lines of hybrids**	1
5.	**Production of breeder seed, foundation seed, certified seed and their quality maintenance**	1
	Unit-II	
6.	**Principles of seed production in self-pollinated crops.**	1
7.	**Principles of seed production in cross-pollinated crops.**	1
8.	**Hybrid seed production: systems and techniques and Seed village concept**	1
9.	Organic seed production and certification.	1
10.	Principles of seed production in field crops: floral structure, pollination mechanism and Seed production techniques in cereals and millets	2
11.	Floral structure, pollination mechanism, and methods and techniques of seed production in major pulses & oilseeds	1
	Unit-III	
12.	Varietal and Hybrid seed production techniques in pigeon pea, mustard, castor and sunflower.	1
13.	Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibre crops	1
14.	Hybrid-seed production techniques in major vegetatively propagated crops	1
15.	Seed certification: history, concept, objectives; Certification Agencies, Phases of Seed Certification: formulation, revision and publication of seed certification standards	1
16.	Minimum seed certification standards and General and specific crop standards, Field and seed standards; Planning and management of	1

	seed certification programs, eligibility of a variety for certification, area assessment, and cropping history of the seed field.	

Practical

S.No.	Topic
1.	Planting design for varietal and hybrid seed production; planting ratio of male and female lines.
2.	Synchronization of parental lines; methods to achieve synchrony.
3.	Identification of rogues and pollen shedders in seed plots.
4.	Supplementary pollination, detasseling, hand emasculation and pollination techniques.
5.	Pollen collection and storage methods; testing pollen viability and stigma receptivity.
6.	Pre-harvest sanitation and identification of maturity symptoms.
7.	Harvesting and post-harvest handling techniques in seed production.
8.	Visit to seed production plots for field exposure.
9.	Visit to seed industries for exposure to seed production chain.
10.	Planning seed production: cost–benefit ratio, seed multiplication ratio and seed replacement rate.
11.	General procedure of seed certification.
12.	Identification of weed and other crop seeds in seed lots.
13.	Field inspection methods at different stages of a crop; recording contaminants.
14.	Inspection and sampling procedures; threshing, processing and after-processing for seed law enforcement.
15.	Specifications of tags and labels used for certification purposes.
16.	Compilation and reporting of seed certification results.

Suggested Reading

- Agrawal PK and Dadlani M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- Agrawal RL. 1997. *Seed Technology,* Oxford & IBH Publishing.
- Anon, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.
- Anon. 1999. *Manual of Seed Certification procedures.* Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi. Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.
- Mc Donald MB and Copeland LO. 1997. *Seed Science and Technology*, Scientific Publisher, Jodhpur.
- Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios (India), Jodhpur, Rajasthan.
- Singhal NC. 2003. *Hybrid Seed Production in Field Crops*, Kalyani Publications, New Delhi Tunwar NS and Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed
- Certification Board, Ministry of Agriculture, New Delhi.

Breeding for Stress Resistance and Climate Change **GPB-516**
Credit Hrs.: 3(2+1)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Concept and importance of climate change; Importance of plant breeding with special reference to biotic and abiotic stress resistance**	1
2.	**Classification of biotic stresses**	1
3	**Major pests and diseases of economically important crops**	1
4.	**Concepts in insect and pathogen resistance**	1
5.	**Analysis and inheritance of resistance variation**	1
6.	**Host defense responses to pathogen invasions- Biochemical and molecular mechanisms**	1
7.	**Acquired and induced immunity and systemic acquired resistance (SAR)**	1
8.	**Host-pathogen interaction**	1
9.	**Gene-for-Gene hypothesis; Molecular evidence for its operation and exceptions**	2
10.	**Concept of signal transduction and other Host-defense mechanisms against viruses and bacteria**	2
11.	**Types and genetic mechanisms of resistance to biotic stresses – Horizontal and vertical resistance in crop plants**	1
12.	**Quantitative resistance/Adult plant resistance and Slow rusting resistance - Classical and molecular breeding methods**	1
13.	**Measuring plant resistance using plant fitness; Behavioral, physiological and insect gain studies**	1
	Unit-II	
14.	**Phenotypic screening methods for major pests and diseases- Recording of observations; Correlating the observations using marker data**	1
15.	**Gene pyramiding methods and their implications**	1
16.	**Classification of abiotic stresses**	1
17.	**Stress-inducing factors – moisture stress/drought and water logging & submergence**	1
18.	Stress-inducing factors - Acidity, salinity/alkalinity/sodicity; High/low temperature, wind, etc	1
19.	Stress due to soil factors and mineral toxicity	1
20.	Physiological and Phenological responses to stresses	1
21.	Emphasis of abiotic stresses in developing breeding methodologies	1
22.	Genetics of abiotic stress resistance	1
23.	Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures	1
	Unit-III	
24.	Utilizing MAS procedures for identifying resistant types in important crops like sorghum/	1
25.	Utilizing MAS procedures for identifying resistant types in important crops like rice and wheat	1

26.	Utilizing MAS procedures for identifying resistant types in cotton	1
27.	Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in water	1
28.	Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil	1
29.	Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in the environment	1
30.	Exploitation of wild relatives as a source of resistance to biotic factors in major field crops	1
31.	Exploitation of wild relatives as a source of resistance to abiotic factors in major field crops	1
32.	Transgenics in the management of biotic and abiotic stresses	1
33.	Use of toxins, protease inhibitors, lectins, and chitinases and Bt for diseases and insect pest management- Achievements	2

Practical

S.No.	Topic
1.	Phenotypic screening techniques for sucking pests and chewing pests -Traits to be observed at plant and insect level
2.	Phenotypic screening techniques for nematodes and borers; Ways of combating them
3.	Evaluating the available populations, like RIL & NIL, for disease & pest resistance
4.	Breeding for herbicide resistance
5.	Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops
6.	Phenotypic screening methods for diseases caused by bacteria: Symptoms and data recording
7.	Phenotypic screening methods for diseases caused by fungi: Symptoms and data recording
8.	Use of MAS procedures for bacteria and fungi
9.	Screening forage crops for resistance to sewage water and tannery effects
10.	Quality parameters evaluation
11.	Screening crops for drought resistance: factors to be considered and breeding strategies
12.	Screening crops for flood resistance: factors to be considered and breeding strategies
13.	Screening varieties of major crops for alkalinity- their effects and breeding strategies
14.	Screening varieties of major crops for acidity and their effects, and breeding strategies
15.	Understanding the climatological parameters and predisposition of abiotic stress factors- ways of combating them

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.
- 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.

Molecular Biology and Biotechnology

Principles of Biotechnology **MBB-501**
Credit Hrs: 3(3+0)
Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**History, scope and importance of Biotechnology**	**1**
2.	**Basics of Biotechnology**	**1**
3.	**Specializations in Agricultural Biotechnology**	**1**
4.	**Genomics**	**1**
5.	**Genetic engineering**	**2**
6.	**Tissue Culture**	**1**
7.	**Bio-fuel**	**1**
8.	**Microbial Biotechnology**	**1**
9.	**Food Biotechnology**	**1**
10.	**Primary metabolic pathways**	**1**
11.	**Enzymes and its activities**	**1**
12.	**Structure of DNA, RNA and protein**	**3**
	Unit-II	
13.	**Physical and chemical properties of DNA, RNA and protein**	**3**
14.	**DNA function: Expression of genetic material Exchange of genetic material**	**2**
15.	**Mutation and its types**	**1**
16.	**DNA modifying enzymes, Vectors introduction**	**1**
17.	**Methods of recombinant DNA technology**	**2**
18.	**Nucleic acid hybridization – Principles and applications**	**2**
19.	DNA libraries (Genomic library), RNA/cDNA libraries	2
20.	Applications of gene cloning in basic and applied research	1
21.	Plant transformation: Gene transfer methods and applications of GM crops	2
22.	Molecular analysis of nucleic acids	1
23.	PCR and its application in agriculture and industry	1
24.	Introduction to Molecular markers: RFLP, RAPD, SSR, SNP etc	2
25.	Applications of molecular markers	1
	Unit-III	
26.	DNA sequencing, different methods	2
27.	Plant cell and tissue culture techniques and their applications	2
28.	Introduction to genomics, transcriptomics,	1
29.	Ionomics, metabolomics and proteomics	1
30.	Genome editing	2
31.	Gene silencing	1
32.	Plant microbial interactions	1
33.	Success stories in Biotechnology Careers	1
34.	Employment in biotechnology, Public perception of biotechnology	1
35.	Bio-safety issues in biotechnology, Bioethics issues in biotechnology	2
36.	Intellectual property rights in biotechnology	1

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

Fundamentals of Molecular Biology — MBB-502

Credit Hrs: 3(3+0)

Theory

S.No.	Topics	No. of lectures
	Unit-I	**1**
1.	**Historical developments of molecular biology**	**1**
2.	**Nucleic acids as genetic material**	**1**
3.	**Chemistry and Nomenclature of nucleic acids**	**1**
4.	**Structure of DNA: primary structure; secondary structure**	**1**
5.	**Forms of DNA: A, B, Z and their function**	**1**
6.	**Structure and Types of RNA**	**2**
7.	**Genome organization in prokaryotes and eukaryotes; DNA Topology**	**1**
8.	**DNA re-association kinetics, Types of repeat sequences**	**1**
9.	**Central dogma of Molecular Biology**	**1**
10.	**DNA replication – Classical experiments**	**2**
11.	**Models of DNA replication**	**1**
12.	**DNA replication – Origin and Steps: initiation, elongation and termination**	**1**
13.	**Enzymes and accessory proteins and its mechanisms**	**1**
14.	**Eukaryotic DNA replication in brief**	**1**
	Unit-II	
15	**Types of DNA damages and mutations**	**1**
16.	**DNA repair mechanisms**	**1**
17.	**Recombination: Homologous and non-homologous, Genetic consequences**	**2**
18.	**Prokaryotic transcription – initiation, elongation and termination, promoters**	**1**
19.	**Structure and function of eukaryotic RNAs and ribosomal proteins**	**1**
20.	Eukaryotic transcription – RNA polymerase I, II, II Elongation and Termination	2
21.	Eukaryotic promoters and enhancers, Transcription factors	1
22.	Post transcriptional processing, Splicing: Catalytic RNAs	1
23.	RNA stability and transport, RNA editing	2
24.	Genetic code and its characteristics	1
25.	Universal and modified genetic code and its characteristics	1
26.	Wobble hypothesis, Translational machinery	2
27.	Ribosomes in prokaryotes and Eukaryotes	2

	Unit-III	
28.	Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes	1
29.	Elongation: translocation, transpeptidation and termination of translation	2
30.	Co-translational modifications of proteins	1
31.	Post-translational modifications of proteins	1
32.	Translational control; Protein stability – Protein turnover and degradation	1
33.	Gene regulation in prokaryotes	2
34.	Constitutive and Inducible expression, Small molecule regulators	1
35.	Operon concept: lac operon	1
36.	Operon concept: trp operon, Attenuation, anti-termination, stringent control	1
37.	Gene regulation in eukaryotes – regulatory RNA	1
38.	RNA interference mechanisms	1
39.	Silencers, insulators, enhancers, Mechanism of silencing and activation	1
40.	Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix etc.	1
41.	Epigenetic regulations	1

Suggested Reading

- Nelson DL and Cox M.M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.
- Allison, L.A. 2011. *Fundamentals of Molecular Biology*. 2nd Edition, John Wiley and Sons.

Molecular Cell Biology — MBB-503

Credit Hrs: 3(3+0)

Theory

S.No.	Topics	No. of lectures
	Unit I	
1.	**Origin of life**	**1**
2.	**History of cell biology**	**1**
3.	**Evolution of the cell: endo-symbiotic theory, Tree of life**	**1**
4.	**General structure and differences between prokaryotic and eukaryotic cell**	**1**
5.	**Similarities and distinction between plant and animal cells**	**1**
6.	**Different kinds of cells in plant and animal tissues**	**1**
7.	**Cell wall and Cell membrane**	**2**
8.	**Structure and composition of bio-membranes**	**1**

9.	**Endoplasmic reticulum and Ribosomes**	**1**
10.	**Golgi apparatus and Mitochondria**	**1**
11.	**Chloroplasts and Lysosomes**	**1**
12.	**Peroxisomes, Micro-bodies and Vacuoles**	**1**
13.	**Nucleus and Cyto-skeletal elements**	**2**
	Unit II	
14.	**Membrane transport – Diffusion and osmosis**	**1**
15.	**Ion channels and active transport**	**1**
16.	**Mechanism of protein sorting**	**2**
17.	**Regulation of intracellular transport**	**1**
18.	**Transmembrane and vesicular transport – endocytosis and exocytosis**	**1**
19.	**General principles of cell communication: hormones and their receptors**	**1**
20.	**Signaling through G-protein coupled receptors**	**1**
21.	Enzyme linked receptors	1
22.	Signal transduction mechanisms and regulation	1
23.	Cell junctions, Cell adhesion, Cell movement, Extracellular matrix	1
24.	Chromatin structure	1
25.	Cell division and regulation of cell cycle	2
26.	Mechanisms of cell division	2
27.	Molecular events at M phase	1
28.	Mitosis and cytokinesis	1
	Unit III	
29.	Ribosomes in relation to cell growth and division	1
30.	Extracellular and Intracellular Control of Cell Division	2
31.	Abnormal cell division: cancer – hallmarks of cancer and role of oncogenes and tumor suppressor genes in cancer development	2
32.	Programmed cell death (Apoptosis)	1
33.	Morphogenetic movements and the shaping of the body plan	1
34.	Cell diversification	1
35.	Cell memory	1
36.	Cell determination and the concept of positional values	1
37.	Differentiated cells and the maintenance of tissues	1
38.	Organ development	1
39.	Stem cells: types and applications	1
40.	Basics of Animal development in model organisms (C. elegans; Drosophila)	1
41.	Plant development	1

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.

Techniques in Molecular Biology I **MBB-504**
Credit Hrs: 3(0+3)
Practical

S.No.	Topics	No. of lectures
1.	Good lab practices. General lab practices	1
2.	Preparation of buffers and reagents	2
3.	Principle of centrifugation	1
4.	Principle of spectrophotometry	1
5.	Growth of bacterial culture, Preparation of growth curve	1
6.	Isolation of Genomic DNA from bacteria	2
7.	Isolation of plasmid DNA from bacteria	2
8.	Growth of lambda phage	1
9.	Isolation of phage DNA	2
10.	Isolation of plant DNA (e.g. Rice / Moong / Mango / Marigold)	2
11.	Restriction of plant genomic DNA	1
12.	Quantification of DNA by Agarose Gel electrophoresis	1
13.	Quantification of DNA by Spectrophotometry	1
14.	PCR using isolated DNA and gel electrophoresis	2
15.	PAGE Gel electrophoresis	1
16.	Restriction digestion of plasmid DNA and phage DNA	1
17.	Ligation and Recombinant DNA construction	1
18.	Transformation of E. coli	1
19.	Selection of transformants	1
20.	Chromatographic techniques – TLC, Gel Filtration Chromatography	2
21.	Chromatographic techniques – Ion exchange Chromatography Affinity Chromatography	2
22.	Dot blot analysis	2
23.	Southern hybridization	4
24.	Northern hybridization	4
25.	Western blotting	2
26.	ELISA	1
27.	Radiation safety and Non-radio isotopic procedure	1

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

Omics and Systems Biology **MBB-505**

Credit Hours: 3 (2+1)

Theory

S.No.	Topics	No. of lectures
	Unit I	
1.	**Different methods of genome sequencing**	**2**
2.	**Principles of various sequencing chemistries**	**1**
3.	**Physical and genetic maps**	**2**
4.	**Comparative and evolutionary genomics**	**2**
5.	**Organelle genomics**	**1**
6.	**Applications in phylogenetics**	**1**
7.	**Case studies of completed genomes, preliminary genome data analysis**	**2**
8.	**Basics of ionomics analysis, different methods**	**1**
9.	**Protein – basics: primary-, secondary- and tertiary structure**	**2**
10.	**Basics of X-ray crystallography and NMR**	**2**
11.	**Principle and Applications of mass spectrometry**	**1**
12.	**Proteomics: Gel based and gel free**	**1**
13.	**Basics of software used in proteomics, MASCOT, PD-Quest, etc.**	**1**
14.	**Study of protein interactions, Prokaryotic and yeast-based expression system and purification**	**1**
	Unit II	
15.	Metabolomics and its applications	1
16.	Use of 1D/2D NMR and MS in metabolome analysis	2
17.	Multivariate analysis and identification of metabolite as biomarkers	1
18.	Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS)	1
19.	X-Ray Fluorescence (XRF) and Neutron activation analysis (NAA)	1
20.	Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome	2
21.	Introductory systems Biology – The biochemical models, genetic models and systems model	1
22.	Unit III	
23.	Molecules to Pathway, Equilibrium binding and cooperativity – Michaelis-Menten Kinetics	1
24.	Biological oscillators, Genetic oscillators, Quorum Sensing, Cell–cell communication	1
25.	Drosophila Development, Pathways to Network	1
26.	Gene regulation at a single cell level, transcription network, REGULATORY CIRCUITS	2
27.	Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis	2

Practical

S.No.	Topics	No. of lectures
1.	Isolation of HMW DNA	**2**
2.	Primary information on genome data analysis	2

3.	BSA Standard curve preparation and Extraction of protein and estimation methods	1
4.	Quantification of proteins from different plant tissues using spectrophotometry	2
5.	2-D Gel Electrophoresis and 2-D Image analysis	1
6.	Experiments on protein-protein interaction (Yeast 2-hybrid)	2
7.	Experiments on protein-protein interaction (Split Ubiquitin system)	1
8.	Demonstration on MALDI-TOF, ICP-MS, AAS, Nitrogen estimation using various methods	2

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.

Plant Tissue Culture — MBB-509

Credit Hrs: 3(2+1)

Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**History of plant tissue culture**	**1**
2.	**Principle of Totipotency**	**1**
3.	**Tissue culture media – composition and types**	**1**
4.	**Plant hormones and morphogenesis**	**1**
5.	**Direct organogenesis, Indirect organogenesis**	**1**
6.	**Direct somatic embryogenesis, Indirect somatic embryogenesis**	**1**
7.	**Applications of plant tissue culture**	**1**
8.	**National certification of TC plants, Quality management of TC plants**	**1**
9.	**Genetic fidelity testing and Virus indexing methods – PCR, ELISA**	**2**
10.	**Micropropagation of field crops**	**2**
11.	**Micropropagation of ornamental crops**	**1**
12.	**Virus elimination – meristem culture. meristem tip culture and micrografting**	**2**
13.	**Androgenesis – production of androgenic haploids**	**1**
14.	**Gynogenesis – production of gynogenic haploids and diploidization**	**1**
	Unit-II	
15.	Protoplast culture – isolation and purification. culture techniques	1
16.	Protoplast fusion	1
17.	Somatic hybridization – production of somatic hybrids and cybrids	2
18.	Wide hybridization – embryo culture and embryo rescue techniques	1
19.	Ovule culture, ovary culture, and endosperm culture	2
20.	Large-scale cell suspension culture – principles, production of alkaloids and other secondary metabolites	2

21.	Unit-III	
22.	Techniques to enhance secondary metabolite production	1
23.	Somaclonal and Gametoclonal variation – causes and applications	1
24.	Callus culture – principles and applications	1
25.	In vitro screening for stress tolerance	1
26.	Artificial seeds – production and applications	1
27.	In vitro germplasm storage, Cryo-preservation – techniques and applications	1
28.	Commercial Tissue Culture – case studies and success stories, market assessment, project planning, economics, and government policies	1

Practical

S.No.	Topics	No. of lectures
1.	Preparation of stocks – macronutrients, micronutrients, vitamins, and hormones	**2**
2.	Filter sterilization of hormones and antibiotics	1
3.	Preparation of Murashige and Skoog medium	2
4.	Micropropagation of plants – nodal culture	2
5.	Micropropagation of plants – shoot tip culture	2
6.	Embryo culture to overcome incompatibility	2
7.	Anther culture for haploid production	1
8.	Callus induction in tobacco leaf discs	1
9.	Regeneration of shoots and root induction; role of hormones in morphogenesis	2
10.	Acclimatization of tissue culture plants	2
11.	Establishment of tissue culture plants in greenhouse	1
12.	Virus indexing in tissue culture plants – PCR and ELISA; Plan of a commercial tissue culture unit.	3

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.

Nano Biotechnology **MBB 514**

Credit Hours: 3 (2+1)

Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Introduction to Nanotechnology**	**1**
2.	**Nanomaterials – overview**	**1**
3.	**Self-assembly to artificial assembly for creation of useful nanostructures**	**1**
4.	**Bottom-up approach – nano rods, nano cages, nanotubes, quantum dots, nanowires**	**1**
5.	**Top-down approach – metal/polymer-based nanostructures**	**1**
6.	**Preparation of nanoparticles**	**1**
7.	**Characterization of nanoparticles – particle size analyzer, microscopy techniques (electron microscopy, atomic force microscopy, etc.)**	**2**
8.	**Cell structure overview**	**1**
9.	**Biomacromolecules – types and structure, dynamics and interaction with water**	**1**
10.	**Cellular nanomachines – concept and examples**	**1**
11.	**Cellular transducers and membrane channels**	**1**
12.	**Membrane transporters and membrane motors**	**1**
13.	**Creation of bio-nanostructures – nano liposomes, nano micelles, nanomotors and other applications**	**1**
	UNIT-II	
14.	Chemical and Physical properties of biomaterials and bioresponse	1
15.	Biological properties of biomaterials – biomineralization and biosynthesis	1
16.	Properties of natural materials – proteins, DNA, and polysaccharides	1
17.	Structure-property relationships in polymeric materials – synthetic polymers	1
18.	Structure-property relationships in polymeric materials – structural proteins	1
19.	Aerosol properties, applications, and dynamics	1
20.	Statistical mechanics in biological systems	1
21.	Nanoparticular carrier systems – principles and applications	1
	UNIT-III	
22.	Micro- and nano-fluidics	1
23.	Drug and Gene delivery systems using nanotechnology	2
24.	Microfabrication techniques	1
25.	Biosensors and chip technologies	1
26.	Nano-imaging techniques	1
27.	Metabolic engineering and gene therapy	1

Practical

S.No.	Topics
1.	Isolation of enzymes involved in biosynthesis of nanomaterials

2.	Isolation of nucleic acids involved in biosynthesis of nanomaterials
3.	Synthesis of gold nanoparticles by biogenic methods
4.	Synthesis of silver nanoparticles by biogenic methods
5.	Synthesis of micelles and inverse micelles
6.	Synthesis of carbon nanomaterials by chemical vapor deposition
7.	Synthesis of carbon nanomaterials by sputtering technique
8.	Preparation of thiolate silver nanoparticles; purification and measurement of carbon nanomaterials
9.	Zinc selenide quantum dot preparation
10.	Synthesis of iron oxide nanoparticles
11.	Thin film preparation by spin coating technique; synthesis of nickel metal nanoparticles by urea decomposition method
12	Synthesis of zinc oxide nanoparticles

Suggested Reading

- Nalwa, H.S. 2005. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*. American Scientific Publications.
- Niemeyer C.M. and Mirkin C.A. (Eds) 2005. *Nanobiotechnology: Concepts Applications and Perspectives,* Wiley Inter-science publications.
- Cao, G., and Wang, Y. 2004. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press.

Plant Pathology

Mycology **PL Path-501**
Credit Hrs.: 3(2+1)
Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
1.	**Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs**	2
2.	**History of mycology**	1
3.	**Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi**	2
4.	**Modern concept of nomenclature and classification**	1
5.	**Classification of kingdom fungi: Stramenopila and Protists**	1
6.	**The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota and Dictyosteliomycota**	1
	UNIT – II	
7.	**The general characteristics of protists and life cycle in the Phyla Acrasiomycota and Myxomycota**	2
8.	**Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota**	1
9.	**Kingdom Stramenopila: characters and life cycles of respective genera under Oomycota**	2
10.	**Kingdom Stramenopila: characters and life cycles of respective genera under Labyrinthulomycota**	2
11.	Kingdom fungi: General characters, ultrastructure and life cycle patterns	2
12.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Chytridiomycota	2
	UNIT – III	
13.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Zygomycota	2
14.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Ascomycota; Archiascomycetes, and Ascomycetous yeasts	2
15.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Ascomycota; Pyrenomycetes, and Plectomycetes	2
16.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Ascomycota; Discomycetes and Loculoascomycetes	2
17.	Kingdom fungi: General characters and ultrastructure and life cycle patterns in representative genera under Ascomycota; Erysiphales and anamorphs of ascomycetous fungi	2
18.	Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes	1

19.	Uredinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts	1
20.	Mitosporic fungi; status of asexual fungi, their teliomorphic relationships	1
21.	Molecular characterization of plant pathogenic fungi	
Total		**32**

Practical:

S. No.	Practical	No. of Lecture
1.	Detailed comparative study of different groups of fungi	1
2.	Collection of cultures and live specimens of fungal diseases in plants	1
3.	Saccardoan classification and classification of fungi based on conidiogenesis	1
4.	Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi	1
5.	Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia	1
6.	Oomycota: Somatic and reproductory structures of Pythium, Phytophthora, downy mildewsand Albugo	2
7.	Zygomycetes: Sexual and asexual structures of Mucor and Rhizopus	1
8.	General characters of VAMfungi	1
9.	Ascomycetes; fruiting structures of order Erysiphales, and Eurotiales	2
10.	General identification characters of Ascomycetes; Pyrenomycetes, Discomycetes, Loculo- ascomycetes and Laboulbenio-mycetes	2
11.	Basidiomycetes: Characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes	2
12.	Deuteromycetes: general characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states	2
13.	Collection, preservation, culturing and identification of plant parasitic fungi	1
14.	Application of molecular approaches and techniques for identification of fungal pathogens	2
Total		20

Suggested Reading

- Ainsworth GC, Sparrow FK and Susman HS. 1973. *The Fungi – An Advanced Treatise*. Vol. IV (A & B). Academic Press, New York.
- Alexopoulos CJ, Mims CW and Blackwell M.2000. *Introductory Mycology.* 5th Ed. John Wiley & Sons, New York.
- Maheshwari R. 2016. *Fungi: Experimental Methods in Biology* 2nd edn. CRC Press, US.
- Mehrotra RS and Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.
- Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.
- Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

Plant Virology **PL Path-502**
Credit Hrs.: 3(2+1)
Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
1.	**History and economic significances of plant viruses**	**2**
2.	**General and morphological characters, composition and structure of viruses**	**2**
3.	**Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions**	**2**
4.	**Origin and evolution of viruses and their nomenclature and classification**	**4**
	UNIT – II	
5.	**Genome organization, replication in selected groups of plant viruses and their movement in host**	**4**
6.	**Response of the host to virus infection: biochemical, physiological, and symptomatical changes**	**3**
7.	Transmission of viruses and virus-vector relationship	3
8.	Isolation and purification of viruses	2
	UNIT – III	
9.	Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques	3
10.	Natural (R-genes) and engineering resistance to plant viruses.	3
11.	Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival)	2
12.	Management of diseases caused by plant viruses	2
	Total	32

Practical

S. No.	Practical	No. of Lecture
1.	Study of symptoms caused by plant viruses (followed by field visit).	1
2.	Isolation and biological purification of plant virus cultures.	1
3.	Bioassay of virus cultures on indicator plants and host differentials.	1
4.	Transmission of plant viruses (Mechanical, graft and vector and study of disease development).	3
5.	Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology.	3
6.	Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR based techniques);	4

7.	Exposure to basic bio-informatics tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedittool, Claustal X/W, MEGA Software).	3
Total		**16**

Suggested Reading

- Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.
- Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ and Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.
- Gibbs A and Harrison B. 1976. *Plant Virology – The Principles*. Edward Arnold, London. Hull
- R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.
- Wilson C. 2014. *Applied Plant Virology.* CABI Publishing England.

Plant Pathogenic Prokaryotes **PL Path-503**
Credit Hrs.: 3(2+1)
Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
1.	**History and development of Plant bacteriology in world as well as in India**	1
2.	**Evolution of prokaryotic life**	1
3.	**Ultra-Structure of bacterial cell**	1
4.	**Structure and composition of gram negative and gram-positive cell wall**	1
5.	**Bacterial cell wall: Synthesis of peptidoglycan, Surface proteins, Lipopolysaccaride structure and Membrane transport**	1
6.	**Bacterial cell: Fimbrae and pili (Type IV pili) and Glycocalyx (S-layer; capsule)**	1
7.	**Bacterial locomotion and movement: Prokaryotic cytoskeletal proteins and mechanism of flagellar rotatory motor**	1
8.	**Bacterial chromosomes and plasmids. Operon and other structures in cytoplasm**	1
9.	**Morphological feature of fastidious bacteria, spiroplasmas and phytoplasmas**	1
	UNIT – II	
10.	**Growth and nutritional requirements of bacteria.**	2
11.	**Infection mechanism, role of virulence factors in expression of symptoms by phyto pathogenic prokaryotes**	2
12.	**Survival and dispersal of phytopathogenic prokaryotes.**	1
13.	**Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy, codes of Nomenclature and characteristics**	1

14.	**Identification, Classification and nomenclature of Bacteria**	1
15.	Identification, Classification and nomenclature of Phytoplasma	1
16.	Identification, Classification and nomenclature of Spiroplasma	1
17.	Biochemical and molecular characterization of phytopathogenic prokaryotes	1
18.	Variability among phytopathogenic prokarya: general mechanism of variability and mutation	1
19.	Specialized mechanisms of variability in bacteria: Sexual reproduction by conjugation, transformation and transduction	2
	UNIT – III	
20.	Horizontal gene transfer in bacteria	1
21.	Bacteriophages: Structure, infection, life cycle and multiplication cycle in host cell; lytic and lysogenic cycle	2
22.	Classification of phages	1
23.	Use of phages in plant pathology/ bacteriology	1
24.	Bdellovibrios: Structure, infection, life cycle and multiplication cycle in host cell	1
25.	L form of bacteria	1
26.	H Plasmids and their types as well as plasmid borne phenotypes in bacteria	1
27.	Introduction to bacteriocins	1
28.	Strategies for management of diseases caused by phytopathogenic prokaryotes	1
	Total	**32**

Practical

S. No.	Practical	No. of Lecture
1.	Study of symptoms produced by phyto pathogenic prokaryotes.	**1**
2.	Isolation and purification of phyto pathogenic bacteria.	**2**
3.	Identification and host inoculation of phytopathogenic bacteria.	**1**
4.	Biochemical and serological characterization of phytopathogenic prokaryotes.	**2**
5.	Isolation of genomic DNA plasmid from bacterial cell.	**2**
6.	Use of antibacterial chemicals/ antibiotics against bacteria.	**1**
7.	Isolation and purification of fluorescent Pseudomonas.	**2**
8.	Preservation of bacterial cultures.	**1**
9.	Molecular identification of prokaryotic organisms by using 16S rDNA, and other gene sequences.	**2**
10.	Diagnosis and management of important diseases caused by bacteria.	**1**
11.	Diagnosis and management of important diseases caused by mollicutes.	**1**
Total		**16**

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.

Plant Nematology **PL Path-504**
Credit Hrs.: 3(2+1)
Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
1.	**Characteristics of Phylum Nematoda and its relationship with other related phyla**	**2**
2.	**history and growth of Nematology**	**2**
3.	**Nematode habitats and diversity- plant, animal and human parasites**	**2**
4.	**Useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry**	**4**
5.	**Gross morphology of plant parasitic nematodes**	**4**
	UNIT – II	
6.	**Broad classification of nematode**	**3**
7.	**Nematode biology, physiology and ecology**	**2**
8.	**Types of parasitism**	**2**
9.	Nature of damage and general symptomatology	2
10.	Interaction of plant-parasitic nematodes with other organisms	2
	UNIT – III	
11.	Plant nematode relationships, cellular responses to infection by important phytonematodes.	2
12.	Physiological specialization among phytonematodes.	2
13.	Principles and practices of nematode management.	1
14.	Integrated nematode management.	1
15.	Emerging nematode problems, Importance of nematodes in international trade and quarantine	**1**
	Total	**32**

Practical

S. No.	Practical	No. of Lecture
1.	Studies on kinds of nematodes-free-living, animal, insect and plant parasites	3
2.	Nematode extraction from soil	3
3.	Extraction of migratory endoparasites, staining for sedentary endoparasites	4
4.	Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology	3
5.	Studies on kinds of nematodes-free-living, animal, Insect and plant	3

	parasites	
Total		**16**

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*, ICAR-AICRP (Nematodes), IARI, New Delhi.

Principles of Plant Pathology — PL Path-505

Credit Hrs.: 3(2+1)

Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
1.	**Importance, definitions and concepts of plant diseases**	**1**
2.	**History and growth of plant pathology**	**1**
3.	**Biotic and abiotic causes of plant diseases**	**1**
4.	**Growth and reproduction of important plant pathogens**	**2**
5.	**Survival of important plant pathogens**	**1**
6.	**Dispersal of important plant pathogens**	**1**
7.	**Role of environment on disease development**	**1**
	UNIT – II	
8.	**Role of host nutrition on disease development**	**1**
9.	**Host parasite interaction, recognition and infection in plants by pathogens**	**2**
10.	**Symptomatology**	**1**
11.	**Role of enzymes and toxins in disease development**	**1**
12.	Role of growth regulators in disease development	1
13.	Defense mechanism: oxidative burst; Phenolics, Phytoalexins	1
14.	Defense mechanism: PR proteins, Elicitors	1
15.	Altered plant metabolism as affected by plant pathogens	1
	UNIT – III	
16.	Principles of plant disease management by cultural, physical, Legal, biological, chemical	2
17.	Resistance methods of plant disease control	1
18.	Application of chemicals on foliage, seed and soil	1
19.	Role of stickers, spreaders and other adjuvants	1
20.	Health vis-a-vis environmental hazards	1

21.	Residual effects and safety measures	1
Total		**24**

Practical

S. No.	Practical	No. of Lecture
1.	Basic plant pathological techniques.	1
2.	Isolation and purification of plant pathogens.	1
3.	Pathogenicity test to prove Koch's postulates.	1
4.	Techniques to study variability in different plant pathogens.	1
5.	Purification of enzymes and their bioassay.	1
6.	Purification of toxins and their bioassay.	1
7.	Estimation of growth regulators in resistant and susceptible plants.	1
8.	Estimation of phenols in resistant and susceptible plants.	1
9.	Estimation of phytoalexins in resistant and susceptible plants.	1
10.	Field evaluation of chemicals, antibiotics, bioagents against plant pathogen.	1
Total		**10**

Suggested Reading

- Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.
- Heitefuss R and Williams PH. 1976. *Physiological Plant Pathology.* Springer Verlag, Berlin, New York.
- Mehrotra RS and Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi. Singh RP. 2012. *Plant Pathology* 2nd edn. Kalyani Publishers, New Delhi.
- Singh RS. 2017. *Introduction to Principles of Plant Pathology*. 5th edn. MedTech, New Delhi. Singh DP and Singh A. 2007. *Disease and Insect Resistance in Plants.* Oxford & IBH, New Delhi.
- Upadhyay RK. and Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology.* Oxford & IBH, New Delhi.

Techniques for Detection and Diagnosis of Plant Diseases — PL Path- 506

Credit Hrs.: 2(0+2)

Practical

S. No.	Practical	No. of Lecture
1.	Detection of plant pathogens based on visual symptoms	1
2.	Detection of plant pathogens based on biochemical test	1
3.	Detection of plant pathogens using microscopic techniques	1
4.	Detection of plant pathogens based on cultural studies; (use of selective media to isolate pathogens).	2
5.	Detection of plant pathogens based on biological assays (indicator hosts, differential hosts).	1
6.	Detection of plant pathogens based on serological assays	1
7.	Detection of plant pathogens based on nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.)	2
8.	Phenotypic and genotypic tests for identification of plant pathogens	1

9.	Molecular identification and whole genome sequencing of prokaryotic organisms (by 16S rDNA and 16s-23S rDNA intergenic spacer region sequences)	2
10.	Molecular identification and whole genome sequencing of eukaryotic organisms by ITS region.	2
11.	Volatile compounds profiling by using GC-MS and LC-MS	1
12.	FAME analysis	1
13.	Fluorescence in-situ Hybridization (FISH)	1
14.	Flow Cytometry	1
15.	Phage display technique	1
16.	Volatile compounds profiling by using GC-MS	1
17.	Volatile compounds profiling by using LC-MS	1
18.	Biosensors for detection of plant pathogens	1
19.	Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL)	2
20.	Electron microscopy techniques of plant virus detection and diagnosis.	1
Total		**25**

Suggested Reading

- Baudoin ABAM, Hooper GR, Mathre DE and Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.
- Dhingra OD and Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.
- Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology,* CABI Wallington.
- Forster D and Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance*. *Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.
- Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.
- Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.
- Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.
- Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.
- Trigiano RN, Windham MT and Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.
- Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

Diseases of Field and Medicinal Crops — PL Path-515

Credit Hrs.: 3(2+1)

Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
Diseases of cereal crops-		
1.	**Rice**	1
2.	**Wheat & Barley**	2
3.	**Pearl millet & Sorghum**	1
4.	**Maize**	1

Diseases of Pulse crop-		
5.	**Gram**	1
6.	**Urdbean, Lentil and Mungbean**	1
7.	**Pigeonpea**	1
8.	**Soybean**	1
9.	**Cowpea**	1
UNIT – II		
Diseases of Oilseed crops		
10.	**Rapeseed and mustard**	1
11.	Sesame and Linseed	1
12.	Sunflower and Castor	1
13.	Groundnut	1
Diseases of Cash crops-		
14.	Cotton	1
15.	Sugarcane	1
UNIT – III		
Diseases of Fodder legume crops-		
16.	Berseem and Oats	1
17.	Guar and Lucerne	1
Diseases of medicinal crops-		1
18.	Plantago, Liquorice and Mulathi	1
19.	Rosagrass, Sacred basil and Mentha	1
20.	Ashwagandha and Aloe vera	1
Total		**22**

Practical

S. No.	Practical	No. of Lecture
1	Detailed study of symptoms and host parasite relationship of important diseases of above-mentioned crops.	5
2	Collection and dry preservation of diseased specimens of important crops.	2
3	Detailed study of symptoms and host parasite relationship of important diseases of above-mentioned crops.	2
Total		**16**

Suggested Reading

- Joshi LM, Singh DV and Srivastava KD. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.
- Rangaswami G. 1999. *Diseases of Crop Plants in India*. 4th Ed. Prentice Hall of India, New Delhi.
- Ricanel C, Egan BT, Gillaspie Jr AG and Hughes CG. 1989. *Diseases of Sugarcane, Major Diseases*. Academic Press, New York.
- Singh RS. 2017. *Plant Diseases*. 10th Ed. Medtech, New Delhi.
- Singh US, Mukhopadhyay AN, Kumar J and Chaube HS. 1992. *Plant Diseases of Internatiobnal Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

Soil Science

Soil Physics **Soil-501**
Credit Hrs.: 3(2+1)
Theory

S.No.	Topic	No. of Lectures
	UNIT-I	
1.	**Basic principles of physics applied to soils, soil as a three-phase system. Soil texture, textural classes, mechanical analysis, specific surface Soil consistence; dispersion and workability of soils**	3
2.	**Soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts; Alleviation of soil physical constraints for crop production. Soil erosion and edibility**	3
3.	**Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability**	2
4.	**Soil tilth, characteristics of good soil tilth; soil crusting mechanism, factors affecting and evaluation;**	2
5.	**Soil conditioners; puddling, its effect on soil physical properties; clod formation**	
	UNIT-II	
6.	**Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water**	2
7.	Soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.	2
8.	Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity	2
9.	Hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils	
10.	Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.	2
	UNIT-III	
11.	Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.	2
12.	Modes of energy transfer in soils; energy balance; thermal properties of soil	2
13.	Measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.	2
	Total-	28

Practical

S.No.	Topic	No. of Lectures
1.	Determination of B.D, P.D and mass volume relationship of soil	1
2.	Mechanical analysis by hydrometer and international pipette method	1

3.	Measurement of Atterberg limits, Aggregate analysis - dry and wet,	1
4.	Measurement of soil-water content by different methods	1
5.	Measurement of soil-water potential by using tensiometer and gypsum Blocks	1
6.	Determination of soil-moisture characteristics curve and computation of pore-size, distribution	1
7.	Determination of hydraulic conductivity under saturated and unsaturated conditions	2
8.	Determination of infiltration rate of soil,	1
9.	Determination of aeration porosity and oxygen diffusion rate	1
10.	Soil temperature measurements by different methods,	1
11.	Estimation of water balance components in bare and cropped fields	1
	Total	**12**

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-Inter science.
- 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.

Soil Fertility and Fertilizer Use — Soil-502

Credit Hrs.: 3(2+1)

Theory:

S.No.	Topics	No. of Lecture
	Unit I	
1.	**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**	3
2.	**Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.**	3
3.	**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**	3

	fertilizer use efficiency.	
4.	**Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid andalkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions**	2
5.	**Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.**	2
	Unit II	
6.	Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.	2
7.	Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.	2
8.	Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.	2
9.	Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management;	2
10.	Integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India	2
	Unit III	
11.	Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture	2
12.	Determination of critical limit, DRIS, Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	2
	Total	**27**

Practical:

S.No.	Topics	Lecture classes
1.	Soil and plant sampling and processing for chemical analysis	3
2.	Determination of soil pH, total and organic carbon in soil	3
3.	Chemical analysis of soil for total and available nutrients (major and micro)	3
4.	Analysis of plants for essential elements (majorandmicro)	3
	Total	**12**

References:

- 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.

Soil Chemistry **Soil-503**

Credit Hrs.: 3(2+1)

Theory:

S.No.	Theory Topics	No. of Lectures
	Unit I	
1.	**Chemical (elemental) composition of the earth's crust, soils, rocks and minerals. Elements of equilibrium thermodynamics**	3
2.	**Chemical equilibria, electrochemistry and chemical kinetics**	3
3.	**Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components**	3
4.	**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**	2
5.	**soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions**	2
	Unit II	
6.	**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**	2
7.	clay-membrane electrodes and ionic-activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange inner sphere and outer-sphere, surface complex formation	2
8.	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	2
	Unit III	
9.	Potassium, phosphate and ammonium fixation in soils covering specific and non- specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/I) relationship; step and constant-rate K; management aspects	2
10.	Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity	2
11.	Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments	2
12.	Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry	2
	Total	**25**

Practical:

S.No.	Topics	Lecture classes
1	Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na	2
2	Determination of CEC and AEC of soils, Analysis of equilibrium soil	2

	solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter	
3	Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances	2
4	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	2
5	Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved	2
6	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	2
7	Determination of gypsum requirement of an alkali soil	2
	Total	**14**

References:

- 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.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.

Soil Minerology, genesis and classification — Soil-504

Credit Hrs.: 3(2+1)

Theory

S. No	Theory topics	Lectures
	UNIT-I	
1.	**Fundamentals of crystallography,**	2
2.	**space lattice and coordination theory**	1
3.	**Isomorphism and polymorphism.**	1
4.	**Classification, structure, chemical composition and properties of clay minerals**	3
5.	**Genesis and transformation of crystalline and non-crystal line clay minerals**	2
6.	**Identification techniques**	1
7.	**Aamorphous soil constituents and other non-crystalline silicate minerals and their identification**	2
8.	**Clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus**	2
9.	**Pesticides and heavy metals**	1

	UNIT-II	
10.	Factors of soil formation, soil formation models	2
11.	Soil forming processes, weathering of rocks and mineral transformations	2
12.	Soil profile; weathering sequences of minerals with special reference to Indian soils	2
	UNIT-III	
13.	Concept of soil individual	1
14.	Soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy;	3
15.	Soil classification,	2
16.	Soil mineralogy and soil maps – usefulness.	1
		28

Practical

1.	Separation of sand, silt and clay fraction from soil	1
2.	Field method of study of soil texture	1
3.	Determination of specific surface area	1
4.	Determination of CEC of clay	1
5.	Identification of minerals	1
6.	Identification of rocks	1
7.	Quantification of minerals in soil fractions	1
8.	Study of different types of landforms	1
9.	Study of an ideal soil profile	1
10.	Morphological properties of soil profile in different land forms	1
11.	Classification of soils using soil taxonomy	2
12.	Calculation of weathering indices and its application in soil formation	1
13.	Grouping soils using available database in terms of soil quality	1
	Total	**14**

Suggested Readding:

- 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.
- Wilding NE and Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy.

Soil Erosion and Conservation **Soil-505**

Credit Hrs.: 3(2+1)

Theory

S. No.	Theory topics	Lectures
	Unit-I	
1.	**Forms of soil erosion; effects of soil erosion**	1
2.	**Factors affecting soil erosion**	1
3.	**Types and mechanisms of water erosion, raindrops and soil erosion, rainfall erosivity.**	2
4.	**Factors affecting water erosion.**	1
5.	**Estimation as EI30 index and kinetic energy**	1
6.	**Empirical and quantitative estimation of water erosion.**	2
7.	**Methods of measurement and prediction of runoff**	
8.	**Soil losses in relation to soil properties and precipitation**	1
	Unit-II	
9.	**Wind erosion- types, mechanism**	2
10.	Factors affecting wind erosion; extent of problem in the country	1
11.	Principles of erosion control; erosion control measures	2
12.	Agronomical and engineering; erosion control structures - their design and layout	2
13.	Soil conservation planning	1
14.	land capability classification	2
15.	Soil conservation in special problem areas such as hilly, arid and semi-arid regions	1
16.	waterlogged and wet lands	2
	Unit-III	
17.	Watershed management - concept, objectives and approach.	1
18.	water harvesting and recycling.	1
19.	flood control in watershed management.	1
20.	socioeconomic aspects of watershed management.	1
21.	case studies in respect to monitoring and Physical Sciences, Soil Science evaluation of watersheds.	1
22.	use of remote sensing in assessment and planning of watersheds, sediment measurement.	1
	Total	**28**

Practical

1.	Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio	2
2.	Determination of clay/moisture equivalent ratio	1
3.	Determination of percolation ratio,	1
4.	Determination of raindrop erodibility index	1
5.	Computation of kinetic energy of falling rain drops	1
6.	Computation of rainfall erosivity index (EI30) using rain gauge data	1
7.	Land capability classification of a watershed	2
8.	Visits to a watershed	1
	Total	**10**

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.

Soil Biology and Biochemistry — Soil-506

Credit Hrs.: 3(2+1)

Theory:

S.No.	Topic	No. of Lectures
	UNIT-I	
1.	**Soil biota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soil biota**	3
2.	**Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance**	3
3.	**Soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR**	
4.	**Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil**	3
5.	**Biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials Cycles of important organic nutrients**	3
	UNIT-II	
6.	**Organic wastes and their use for production of biogas and manures;**	2
7.	Biotic factors in soil development; microbial toxins in the soil.	2
8.	Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.	2
9.	Biofertilizers–definition, classification, specifications, method of production and role in crop production	2
10.	FCO specifications and quality control of biofertilizers.	2
	UNIT-III	
11.	Biological indicators of soil quality; bioremediation of contaminated soils	2
12.	Microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis – important mechanisms and controlling factors	2
13.	Soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil	2
	Total-	28

Practical

S.No.	Topic	No. of Lectures
1.	Determination of soil microbial population	1
2.	Estimation of Soil microbial biomass carbon	2
3.	Elemental composition of organic matter	1
4.	Fractionation of organic matter and functional groups	2
5.	Decomposition of organic matter in soil	1
6.	Estimation of Soil enzymes	1
7.	Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation2	2
8.	Measurement of S oxidation, P solubilization and mineralization of other micronutrients	
	Total-	12

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
  Gulam Hasandar, Soil Biology and Biochemistry

Soil Survey and Land Use Planning **SOIL-513**
Credit Hrs.: 3(2+1)
Theory

S. No.	topics	Lectures
	UNIT-I	
1.	**Soil survey and its types;**	2
2.	**soil survey techniques- conventional and modern**	1
3.	**soil series–characterization and procedure for establishing soil series**	2
4.	**benchmark soils and soil correlations**	1
5.	**Soil survey interpretations;**	1
6.	**Thematic soil maps and cartography**	1
7.	**Mapping units,**	1
8.	**Techniques for generation of soil maps,**	1
9.	**Application of remote sensing and GIS in soil survey**	1
10.	**Mapping of major soil group of India**	1
	UNIT -II	
11.	**Landform–soil relationships**	1
12.	**Major soil groups of India with state-specific reference to M.P**	1
13.	Land capability classification	1
14.	Land irrigability classification	1
15.	Land evaluation and Land Use Type (LUT): concept and application	1
16.	Concept and techniques of land use planning	1

17.	Factors governing present land use	1
18.	Methods of land evaluation	2
	UNIT- III	
19.	Soil-site suitability evaluation for different crops	2
20.	Constraints in the application of land capability classification	1
21.	Agro-ecological regions and sub-regions of India	
22.	Characteristics of regions in relation to crop production	1
23.	Status and progress of Land Use Planning (LUP) in India.	1
	Total	**26**

Practical

1.	Aerial photo and satellite data interpretation for soil and land use	2
2.	Cartographic techniques for preparation of base maps and thematic maps	1
3.	processing of field sheets,	1
4.	Land use planning exercises using conventional and RS tools	2
5.	Compilation and obstruction of maps in different scales	1
6.	Field visit	2
	Total	**9**

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.
- Sys, c 1991. land evaluation vol I, II, III General Administration for Development Cooperation, 1991

Horticulture (Floriculture and Landscaping)

Systematics of Ornamental Plants **FLS-501**
Credit Hrs.: 3 (2+1)
Theory:

S. No.	TOPIC	No. of Lecture
	Unit -I	
1.	**Nomenclature: History and origin**	2
2	**Hotspots**	1
3	**Classification and nomenclature systems**	2
4.	**International systems: International Code, Treaties, International and National Organisations**	3
5	**Biodiversity Act, Identification features, descriptors.**	3
6	**Red Book, Registration (NBPGR, PPVFRA, NBA).**	3
	Unit - II	
7.	**Families: Description and families and important genera Rosaceae, Asteraceae**	2
8.	Caryophyllaceae, Orchidaceae	2
9.	Aracaceae, Liliacae	2
10.	Acanthaceae, Palmaceae	2
11.	Asparagaceae, Malvaceae	2
12.	Musaceae Oleaceae	2
13.	Iridaceae	1
	Unit - III	
14.	Molecular techniques in modern systematics.	3

Practical

1.	Different nomenclature systems of plants
2.	Floral biology and taxonomic description of rose and chrysanthemum
3.	Floral biology and taxonomic description of orchids and carnation
4.	Floral biology and taxonomic description of gerbera and anthurium
5.	Floral biology and taxonomic description of marigold and tuberose
6.	Floral biology and taxonomic description of Jasmine and China aster
7.	Floral biology and taxonomic description of lilium and gypsophila
8.	Cryopreservation and tissue culture repository
9.	Molecular techniques

Suggested Reading

- Bhattacharya B and Johri BM. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Publ. House, New Delhi, India. pp.753.
- Dutta AC. 1986. *A Class Book of Botany*. Oxford Univ. Press, Kolkata, India.
- Pandey BP. 2013. *Taxonomy of Angiosperms*. S. Chand & Co. pp. 608.
- Rajput CBS and Haribabu RS. 2014. *Citriculture*, Kalyani Publishers, New Delhi, India.
- Spencer RR, Cross R and Lumley P. 2007. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature*. CSIRO Publ., Australia., 176 p.
- Vasistha BB. 1998. *Taxonomy of Angiosperms*. Kalyani Publishers, New Delhi, India.

Breeding of Ornamental Plants **FLS-502**
Credit Hrs.: 3 (2+1)
Theory:

S. No.	TOPIC	Lecture
	Unit- I	
1.	**Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops**	3
2.	**Introduction and initiatives in IPR and PBR of ornamental crops**	2
3.	**Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major ornamental crops like rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lilium, marigold, jasmine, tuberose, dahlia, gaillardia, crossandra, aster etc.**	3
4.	**Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major flowering annuals like petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus etc.**	3
	Unit II	
5.	**Breeding objectives, reproductive barriers (Male sterility, incompatibility) in Important ornamental crops like aglaonema, diffenbachia, hibiscus, bougainvillea, tecoma, kalanchoe etc.**	3
6.	**Inheritance of important traits, Genetic mechanisms associated with flower colour, size, form, doubleness, fragrance, plant architecture, post-harvest life, abiotic and biotic stress tolerance/ resistance**	3
7.	Breeding methods suitable for sexually, asexually propagated flower crops.	3
8.	Breeding methods suitable for self - and cross- pollinated crops.	2
	Unit III	
9.	Pedigree selection, backcross, clonal selection	3
10.	Polyploidy and Mutation breeding	2
11.	Heterosis and F1 hybrids	2
12	Role of biotechnology in improvement of flower crops including soma clonal variation, *in-vitro* mutagenesis, *in-vitro* selection, genetic engineering, molecular markers, etc.	3
Crops- rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lilium, marigold, jasmine, tuberose, dahlia, gaillardia, crossandra, aster etc., Flowering annuals: petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus etc. Important ornamental crops like aglaonema, diffenbachia, hibiscus, bougainvillea, tecoma, kalanchoe etc.		

Practical

1.	Floral biology of important ornamental crops,	2
2.	Cytology and cytogenetic.	2
3.	Selfing and crossing procedures for important ornamental crops.	2
4.	Evaluation of hybrid progenies.	2

5.	Induction of mutants through physical and chemical mutagens.	2
6.	*In vitro* selection, genetic engineering.	2
7.	Induction of polyploidy.	2
8.	DUS testing.	2

Suggested Readings

- De LC. 2019. Ornamental Crop Breeding. Aavishkar Publishers and Distributors, Jaipur,
- Rajasthan.
- Singh BD. 2006. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi.
- Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Pointer Publ., Reprint, 6 vols, pp. 2065.
- Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants.* Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
- Chadha KL and Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp.584.
- Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.
- Vainstein A. (Ed). 2002. *Breeding for ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. Edition 1. pp. 392.
- Watts L. 1980. *Flower and Vegetable Plant Breeding*. Unilever Research, Sharnbrook, Bedford, UK. pp 182. Grower Books, London, UK.

Commercial Production of Cut Flowers FLS-503

Credit Hrs.: 3 (2+1)

Theory:

Sl. No.	TOPIC	No. of Lecture
	Unit-I	
1.	**Scope and importance of commercial floriculture in India**	2
	Production technology (Environment, open cultivation, protected cultivation, soil/ media requirements, land preparation, planting methods, influence of light, temperature, moisture, humidity and microclimate management on growth and flowering. **Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, ratooning, training and pruning, pinching, deshooting, bending, desuckering, disbudding. Use of growth regulators, physiological disorders and remedies, IPM and IDM., Flower forcing and year round/ offseason flower production through physiological interventions, chemical regulation, environmental manipulation.** **Post harvest management: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, storage and transportation) of rose**	4
2.	**Production technique of chrysanthemum**	2

3.	**Production technique of gladiolus**	2
4.	**Production technique of tuberose**	1
	Unit-II	
5.	**Production technique of carnation**	2
7.	**Production technique of gerbera**	2
8.	**Production technique of orchids**	2
9.	Production technique of lilium	2
10.	Production technique of anthurium	2
	Unit-III	
11.	Production technique of china aster	1
12.	Production technique of alstroemeria	1
13.	Production technique of bird of paradise	1
14.	Production technique of heliconia	1
15.	Production technique of ornamental ginger	1
16.	Production technique of dahlia	1
17.	Production technique of gypsophila	1
18.	Production technique of cut greens and fillers.	1
19.	Marketing, export potential, institutional support, Agri Export Zones, 100% Export Oriented units, Crop Insurance.	3

Practical

1.	Identification of varieties	1
2.	Propagation	2
3.	Microclimate management	2
4.	Training and pruning techniques	1
5.	Pinching, deshooting, disbudding, desuckering	1
6.	Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application	2
7.	Harvesting techniques, post-harvest handling, cold chain	2
8.	Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines)	2
9.	Visit to commercial cut flower units	2
10.	Case studies	1

Suggested readings

- Arora JS. 2010. Introductory Ornamental Horticulture. Kalyani Publishers. 6th edition, pp.230.
- Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp.584.
- Singh A K 2006 Flower Crops: Cultivation and Management, New India Publishing, Gardening- 480 p.
- Purohit S S and Bhardwaj Prasad R L A 2016. Textbook of Production Technology of Vegetable and Flower Crops Agrobios (India); 400 p.
- Randhawa, G. S. and Mukhopadhyay Amitabha 1986. Floriculture in India, Allied Publishers, - 660 p.

Commercial Production of Loose Flowers **FLS-504**
Credit Hrs.: 3 (2+1)
Theory:

Sl. No.	TOPIC	No. of Lecture
	Unit- I	
1.	**Scope, scenario and importance of loose flowers, constraints and opportunities in loose flower production in India**	2
	Production technology (Nursery management, pro-tray nursery under shade nets, soil and climate requirement, Field preparation, systems of planting. Soli analysis, soil health card, water and nutrient management, weed management, training and pruning, special horticultural practices such as pinching and disbudding, use of growth regulators, physiological disorders and remedies, INM, IPM and IDM. Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation. Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packaging and storage) of rose	2
2.	**Production technique of marigold**	2
3.	**Production technique of chrysanthemum**	2
4.	**Production technique of jasmine**	3
	Unit II	
5.	**Production technique of tuberose**	1
7.	**Production technique of china aster**	1
8.	**Production technique of crossandra**	1
9.	**Production technique of gaillardia**	1
10.	Production technique of spider lily	1
11.	Production technique of hibiscus and nerium	2
12.	Production technique of barleria and celosia	2
	Unit III	
13.	Production technique of gomphrena and madar (*Calotropis gigantea*),	1
14.	Production technique of nyctanthes (Harsingar) and tabernaemontana (Chandni)	1
15.	Production technique of lotus and water lily	2
16.	Production technique of michelia (Champa) and gardenia	1
17.	Production technique of ixora	1
18.	Production technique of balsam.	1
19.	Important local markets, Export potential, transportation and marketing, APMC and online trading, institutional support, Crop Insurance.	3

Practical		
1.	Identification of species and varieties	1
2.	Propagation and nursery management	1
3.	Training and pruning techniques	1
4.	Fertigation, foliar nutrition, growth regulator application	2
5.	Crop protection	2
6.	Pinching, disbudding, staking, harvesting techniques	1
7.	Post-harvest handling, storage and cold chain	2

8.	Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines)	2
9.	Cost Economics	2
10.	Exposure Visits to fields	2

Suggested Reading

- Arora JS. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230. Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.
- Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
- Chadha KL and Bhattacharjee S K. 1995. *Advances in Horticulture: Ornamental Plants.* Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
- Chadha KL and Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India. Laurie A and Rees VH. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur. pp.534.
- Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa GS and Mukhopadhyay A. 2001. *Floriculture in India*. Allied Publ. pp 660.

Ornamental Gardening and Landscaping — FLS-505

Credit Hrs.: 3 (2+1)

Theory:

S. No.	TOPIC	No. of Lecture
	Unit-I	
1.	**Historical background of gardening**	1
2.	**Importance and scope of ornamental gardening**	1
3.	**Styles and types of gardens formal and informal style gardens**	1
4.	**English, Mughal and Japanese gardens.**	2
5.	**Persian, Spanish, Italian, French, Hindu and Buddhist gardens**	1
6.	**Garden components (living and non-living): annual, shrub, tree, fern, palm, climbers and creepers, cacti and succulents, ground covers**	4
7.	**Arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges. Herbs, flower borders and beds, carpet beds, colour wheels, clock garden, bamboo groves**	1
10.	**Bonsai**	1
	Unit-II	
11.	**Non -living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps**	1
12.	**Lawn -genera and species, establishment and maintenance**	2
13.	**Specialized gardens such as vertical garden**	1
14.	Roof garden, terrace garden, water garden.	1
15.	Sunken garden, rock garden, shade garden.	1
16.	Temple garden, sacred gardens (with emphasis on native plants), Zen garden	1

17.	Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, Steps in preparation of garden design, programmes phase, design, phase, etc.	2
18.	Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis	1
	Unit-III	
19.	Principles of circulation, site analysis and landscape, water requirement, use of recycled water	1
20.	Urban landscaping	1
21.	Landscaping for specific situations such as residential, farm houses, institutions,	1
22.	Landscaping for corporate sector, industries, hospitals, roadsides, traffic islands,	2
23.	Landscaping for children parks, public parks, xeriscaping,	1
24.	Landscaping for airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks.	2
25.	Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening.	2

Practical		
1.	Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc.	1
2.	Identification of various types of ornamental plants for different gardens and occasions	1
3.	Preparation of land, planning, layout and planting, deviations from landscape principles	1
4.	Case study	1
5.	Site analysis, interpretation of map of different sites, use of GIS for selection	1
6.	Enlargement from blue print. Landscape design layout and drafting on paper as per the scale	2
7.	Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.	3
8.	Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders	2
9.	Project preparation on landscaping for different situations, creation of formal and informal gardens	2
10.	Visit to parks and botanical gardens	2

Suggested Reading

- Bose TK, Chowdhury B and Sharma SP. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.
- Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.
- Grewal HS and Singh P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publishers, New Delhi.
- Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.*Agrobios Publ., Jodhpur.

- Misra RL and Misra S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India. Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.
- Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Sabina GT and Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi, India.
- Singh A and Dhaduk BK. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ. Agency, New Delhi, India.

Nursery Management for Ornamental Plants FLS-507

Credit Hrs.: 3 (2+1)

Theory

S. No.	TOPIC	No. of Lecture
	Unit I	
1.	**Importance and present scenario and status of nursery industry in India and in the world**	1
2.	**Life cycles in plants, Propagation methods**	1
3.	**Sexual propagation: Factors influencing seed germination of flower crops, dormancy, seed quality, packing, storage, certification, testing**	2
4.	**Hormonal regulation of germination and seedling growth**	1
5.	**Asexual propagation: Methods of asexual propagation, rooting of soft and hard wood cutting under mist**	2
6.	**Role of Plant growth regulators**	1
7.	**Physiological, anatomical and biochemical aspects of root induction in cuttings**	1
8.	**Layering – principles and methods**	1
9.	**Budding and grafting – selection of elite mother plants**	1
10.	**Stock, scion and inter stock, relationship – Incompatibility**	1
	Unit II	
11.	**Micro-propagation – principles and concepts, commercial exploitation in flower crops**	1
12.	**Techniques – *in-vitro* clonal propagation**	1
13.	**Direct organogenesis, embryogenesis**	2
14.	Micrografting, meristem culture.	2
15.	Hardening, packing and transport of micro-propagules.	1
16.	Growing structures like mist chambers, tunnels, lath house, net house	1
17.	Growing media types, soil less culture and containers	1
18.	Automation in nursery management	1
	Unit III	
19.	Nursery – types, components, planning and layout.	2
20.	Nursery management practices for healthy propagule production	1
21.	Nursery Act and PPV&FR Act	2
22.	Quarantine system in India	1
23.	Important quarantine pests and diseases	1
24.	Sanitary and phyto-sanitary issues threats to nursery Industry.	1

25.	Nursery standards, Hi-tech nurseries, garden centers	2

Practical

1.	Anatomical studies in rooting of cutting and graft union	2
2.	Identification and production of plug plants, seedlings and saplings	2
3.	Preparation of growing media and use of PGRs	2
4.	Practice of propagation through specialized structures cuttings, layering, budding and grafting	2
5.	Case studies	2
6.	Micropropagation of ornamental crops and hardening	3
7.	Visit to tissue culture labs and nurseries	2
8.	Economics	1

Suggested Reading

- 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.
- Chadha KL, Ravindran PL and Leela Sahijram. 2000. *Biotechnology in Horticulture and Plantation Crops*. Malhotra Publ. House, New Delhi, India.
- Davies Fred T Jr., Geneve RL, Wilson SB, Hartmann HT and Kester DL. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices.* Pearson Publ. 9th Edition.
- Peter KV. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi, India.
- Rajan S and Baby LM. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency, New Delhi, India. pp. 251.
- Singh SP. 1989. *Mist Propagation*. Metropolitan Book Co., New Delhi, India.

Value Addition in Floriculture — FLS-509

Credit Hrs.: 3 (2+1)

Theory:

S. No.	TOPIC	No. of Lecture
	Unit I	
1.	**Scope and prospects of value addition, National and global scenario, production and exports.**	2
2.	**Types of value-added products**	1
3.	**Techniques of value addition including tinting**	2
4.	**Value addition in loose flowers and product development- Gulkhand, floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, etc.**	3
5.	**Selection of containers and accessories for floral products and decorations. Flower arrangement, styles, ikebana schools (*ikenobo, ohara, sogetsu*, etc.), Ikebana- moribana, nagiere, contemporary style**	6
	Unit II	
5.	**Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; tips for collecting dry flower making, selection of stages for**	3

	picking of flowers for drying Accessories	
6.	Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing	2
7.	Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers	2
8.	Packaging and storage. Post drying management including moisture, pests and molds.	2
9.	Essential oils; selection of species and varieties (including nonconventional species), extraction methods, packing and storage, aromatherapy	2
	Unit III	
10.	Types of pigments, carotenoids, anthocyanins, chlorophyll, betalains	2
11.	Significance of natural pigments as nutraceuticals	2
12.	Extraction methods and applications in food, pharmaceutical and poultry industries	2
13.	Synthetic and natural dyes, dying techniques, colour retention	1

Practical		
1.	Practices in preparation of different type of flower arrangements including bouquets, buttonholes, flower baskets, corsages, floral wreaths, garlands with fresh flowers	3
2.	Techniques in flower arrangement and floral decoration	2
3.	Identification of plants for dry flower making	1
4.	Practices in dry flower making	2
5.	Preparation of dry flower baskets, bouquets, potpourri, wall hangings, button holes, greeting cards, wreaths, etc.	2
6.	Preparation of epoxy resin encapsulated products	1
7.	Dehydration of foliage (with 20 % glycerol)	1
8.	Essential oil extraction units.	1
9.	Extraction of pigments	1
10.	Visit to dry flower units	1
11.	Economics of value-added products	1

Suggested Readings

- Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants.* Vol. XII, Parts 1 & 2. pp.533 and pp.574. Malhotra Publ. House, New Delhi, India.
- Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.* Agrobios Publ., Jodhpur.
- Nowak J and Rudnicki RM. 1990. *Postharvest handling and storage of cut flowers, florist greens, and potted plants*. Timber Press, USA. pp. 210.
- Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.
- De LC. 2019. Value Addition in Flowers and Orchids- New India Publishing Agency.
- Gupta Sachi, Pathak Sanjay and Yadav Atul. 2019. Advances and value addition in flower crops. Weser Books.

Horticulture (Fruit Science)

Tropical Fruit Production **FSC-501**
Credit hours: 3(2+1)
Theory

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Importance, history, scope and commercial importance of tropical fruits in the world and India**	**2**
2.	**Production techniques (Origin, distribution, and eco-physiological requirements, major species, rootstocks, commercial varieties of regional, national and international importance. Propagation methods, planting systems and densities, training and pruning, rejuvenation, intercropping, nutrient and water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic, factors limiting fruit production, physiology of flowering, pollination management, fruit set and development, crop regulation, quality improvement by management practices, physiological disorders-causes and remedies, maturity indices, harvesting, grading, packing, storage and ripening techniques, insect and disease management) of Mango fruit crop**	**4**
3.	**Production techniques of Banana fruit crop**	**3**
4.	**Production techniques of Guava fruit crop**	**3**
	UNIT-II	
5.	**Production techniques of Pineapple fruit crop**	**2**
6.	Production techniques Papaya fruit crop	3
7.	Production techniques of Avocado fruit crop	3
	UNIT-III	
8.	Production techniques of Jackfruit fruit crop	2
9.	Production techniques of Annonas fruit crops	2
10.	Production techniques of Aonla fruit crop	2
11.	Production techniques of Ber fruit crop	2

Practical

S. No.	Topic	No. of Lectures/ practice
1.	Distinguished features of fruit species, cultivars and rootstocks of tropical fruit crops	3
3.	Demonstration of planting systems	1
4.	Demonstration of training and pruning	2
5.	Hands on practices on pollination and crop regulation	2
6.	Leaf sampling and nutrient analysis	3
7.	Physiological disorders-malady diagnosis	1
8.	Physico-chemical analysis of fruit quality attributes	3
9.	Field/ Exposure visits to tropical orchards	1
10.	Project preparation for establishing commercial orchards	1

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.

Subtropical and Temperate Fruit Production — FSC-502

Credit hours: 3(2+1)

Theory

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Importance, history, scope and commercial importance of sub-tropical and temperate fruits**	**1**
2.	**Distribution of sub-tropical and temperate zones in the world and India.**	**1**
3.	**Production techniques (Origin, distribution, and eco-physiological requirements, major species, rootstocks, commercial varieties of regional, national and international importance. Propagation, planting systems and densities, training and pruning, rejuvenation and replant, intercropping, nutrient and water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination management, fruit set and development, crop regulation, quality improvement by management practices, physiological disorders-causes and remedies,-maturity indices, harvesting, grading, packing, storage and ripening techniques, insect and disease management) of Citrus crop**	**3**
4.	**Production techniques of Grape fruit crop**	**2**

5.	**Production techniques of Litchi fruit crop**	**2**
6.	**Production techniques of Pomegranate fruit crop**	**1**
7.	**Production techniques plum fruit crop**	**2**
	UNIT-II	
8.	**Production techniques of Apple fruit crop**	**3**
9.	**Production techniques of Pear fruit crop.**	**2**
10.	Production techniques of Peach fruit crop	2
11.	Production techniques of Apricot fruit crop	2
12.	Production techniques of Cherries fruit crop	2
	UNIT-III	
13.	Production techniques of Kiwi fruit crop	2
14.	Production techniques of Persimmon, strawberry and berries fruit crops	2
15.	Production techniques of Walnut crop	2
16.	Production techniques of Almond crop	1
17.	Production techniques of Pecan nut, Hazelnut and Chestnut	2

Practical

S. No.	Topic	No. of Lectures
1.	Distinguished features of fruit species, cultivars and rootstocks of subtropical fruit crops	1
2.	Distinguished features of fruit species, cultivars and rootstocks of temperate fruit crops	1
3.	Distinguished features of fruit species, cultivars and rootstocks of nut crops	1
4.	Demonstration of planting systems	1
5.	Demonstration of training and pruning	1
6.	Hands on practices on pollination and crop regulation	2
7.	Leaf sampling and nutrient analysis	3
8.	Physiological disorders-malady diagnosis	1
9.	Physico-chemical analysis of fruit quality attributes	3
10.	Field/ Exposure visits to subtropical and temperate orchards	1
11.	Project preparation for establishing commercial orchards	1

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.

Propagation and Nursery Management of Fruit Crops FSC-503

Credit Hrs.: 3(2+1)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Introduction, understanding cellular basis for propagation, sexual propagation asexual propagation**	2
2.	**Apomixis, polyembryony and chimeras**	1
3.	**Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth**	2
4.	**Seed quality, treatment, packing, storage, certification and testing**	2
5.	**Cutting– methods**	1
6.	**Rooting of soft and hardwood cuttings under mist and hotbeds**	2
7.	**Use of PGR in propagation**	1
8.	**Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods**	2
	Unit-II	
9.	**Budding and grafting – principles and methods**	4
10.	Establishment and management of bud wood bank	1
11.	Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock top working	3
12.	Micro-propagation – principles and concepts, commercial exploitation in horticultural crops	1
13.	Techniques – in-vitro clonal propagation, direct organogenesis, embryogenesis, micro-grafting, meristem culture, genetic fidelity testing	3
14.	Hardening, packaging and transport of micro-propagules	1
	Unit-III	
15.	Nursery – types, structures, components, planning and layout	1
16.	Nursery management practices for healthy propagule production	2
17.	Nursery Act and nursery accreditation	1
18.	Import and export of seeds and planting material and quarantine	2

Practical

S.No.	Topic	No. of Lecture
1.	Hands on practices on rooting of dormant and summer cuttings	3
2.	Anatomical studies in rooting of cutting and graft union	1
3.	Hands on practices on various methods of budding and grafting	4
4.	Propagation by layering and stooling	2
5.	Micro-propagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening	4
6.	Visit to commercial tissue culture laboratories and accredited nurseries	2

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 Propagation- Principles 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.

Breeding of Fruit Crops FSC-504

Credit Hrs.: 3(2+1)

Theory

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Taxonomical status – species and cultivars, cytogenetics, genetic resources**	**2**
2.	**Blossom biology of fruit crops**	**1**
3.	**Breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives and ideotypes of fruit crops**	**2**

4.	**Breeding approaches for mango crop improvement (direct 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 thrusts)**	**2**
5.	**Breeding approaches for banana crop improvement**	**2**
	UNIT-II	
6.	**Breeding approaches for citrus crop improvement**	**3**
7.	**Breeding approaches for grape crop improvement**	**2**
8.	**Breeding approaches for litchi crop improvement**	**1**
9.	**Breeding approaches for guava crop improvement**	**1**
10.	Breeding approaches for pomegranate crop improvement	1
11.	Breeding approaches for papaya crop improvement	2
12.	Breeding approaches for apple crop improvement	2
	UNIT III	
13.	Breeding approaches for pear crop improvement	2
14.	Breeding approaches for plum crop improvement	1
15.	Breeding approaches for peach crop improvement	1
16.	Breeding approaches for apricot crop improvement	1
17.	Breeding approaches for cherry crop improvement	1
18.	Breeding approaches for strawberry crop improvement	2
19.	Breeding approaches for kiwi crop improvement	1
20.	Breeding approaches for nuts improvement	2

Practical

S. No.	Topic	No. of Lectures/ Hands on practice
1.	Exercises on bearing habit and floral biology	2
2.	Pollen viability and fertility studies	1
3.	Hands on practices in hybridization	3
4.	Raising and handling of hybrid progenies	2
5.	Induction of mutations and polyploidy	2
6.	Evaluation of biometrical traits and quality traits	2
7.	Screening for resistance against abiotic stresses	2
8.	Developing breeding programme for specific traits	2
9.	Visit to research stations working on fruit breeding	1

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.

Canopy Management in Fruit Crops FSC-506

Credit Hrs.:2 (1+1)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Importance and factors affecting canopy development**	**1**
2.	**Canopy types and structures**	**2**
3.	**Canopy manipulation for optimum utilization of light and its interception**	**2**
	Unit-II	
6.	**Spacing and utilization of land area – Canopy classification**	**2**
7.	**Canopy management through rootstock and scion**	**2**
8.	Canopy management through plant growth regulators	2
	Unit-III	
9.	Canopy management through training and pruning and management practices	2
10.	Canopy development and management in relation to growth, flowering, fruiting and fruit quality	2

Practical

S.No.	Topic	No. of Lecture
1.	Study of different types of canopies	2
2.	Training of plants for different canopy types	2
3.	Canopy development through pruning	2
4.	Understanding bearing behaviour and canopy management in different fruits	2
5.	Use of plant growth regulators	2
6.	Geometry of planting	1
7.	Development of effective canopy with support system	2
8.	Study on effect of different canopy types on production and quality of fruits	2

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

Growth and Development of Fruit Crops — FSC- 507

Credit Hrs.: 3(2+1)

Theory

S.No.	Topic	No. of Lectures
	Unit-I	
1.	**Growth and development- definition, parameters of growth and development**	**2**
2.	**Growth dynamics and morphogenesis**	**2**
3.	**Environmental impact on growth and development- effect of light, temperature and photosynthesis**	**4**
4.	**Photoperiodism, vernalisation, heat units and thermoperiodism**	**3**
5.	**Assimilate partitioning, influence of water and mineral nutrition in growth and development**	**3**
	Unit-II	
6.	**Concepts and history of plant hormone and bio-regulators**	**2**
7.	Biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs	4
8.	Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development	4
	Unit-III	
9.	Growth and developmental process during stress – manipulation of growth and development	2
10.	Impact of pruning and training	2
11.	Chemical manipulations and Commercial application of PGRs in fruit crops	1
12.	Molecular and genetic approaches in plant growth and development.	2

Practical

S.No.	Topic	No. of Lecture
1.	Understanding dormancy mechanisms in fruit crops and seed stratification	2
2.	Techniques of growth analysis	2
3.	Evaluation of photosynthetic efficiency under different environments	2
4.	Exercises on hormone assays	2
5.	Practicals on use of growth regulators	2
6.	Understanding ripening phenomenon in fruits	2
7.	Study on impact of physical manipulations on growth and	1

	development	
8.	Study on chemical manipulations on growth and development	1
9.	Understanding stress impact on growth and development	1

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, NY, USA.
- Dhillon WS and Bhatt ZA. 2011. *Fruit Tree Physiology.* Narendra Publishing House, New Delhi. Durner E. 2013. *Principles of Horticultural Physiology.* 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.

Minor Fruit Production FSC-513

Credit hours: 3(2+1)

Theory

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Importance, occurrence and distribution, climate adaptation in fragile ecosystem and wastelands of fruit crops**	**2**
2.	**Package of practices, utilization and marketing (traditional cultural practices and recent development in agro-techniques, propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality, post-harvest management, marketing, minor fruit crops in terms of medicinal and antioxidant values, their uses for edible purpose and in processing industry) of Bael fruit crop**	**1**
3.	**Package of practices, utilization and marketing of Chironji fruit crop**	**2**
4.	**Package of practices, utilization and marketing of Fig fruit crop**	**2**
5.	**Package of practices, utilization and marketing of Passion fruit**	**2**
6.	**Package of practices, utilization and marketing of Jamun fruit crop**	**1**
	UNIT-II	
7.	**Package of practices, utilization and marketing of Phalsa fruit**	**1**

	crop	
8.	**Package of practices, utilization and marketing of Karonda fruit crop**	**1**
9.	**Package of practices, utilization and marketing of Wood apple fruit crop**	**1**
10.	**Package of practices, utilization and marketing of Cactus pear fruit crop**	**1**
11.	**Package of practices, utilization and marketing of Khejri, Kair and Pilu fruit crop**	**3**
12.	Package of practices, utilization and marketing of Lasoda and Loquat fruit crop	2
13.	Package of practices, utilization and marketing of Tamarind fruit crop	1
14.	Package of practices, utilization and marketing of Dragon fruit crop	1
	UNIT III	
15.	Package of practices, utilization and marketing of Monkey jack fruit crop	1
16.	Package of practices, utilization and marketing of Mahua fruit crop	1
17.	Package of practices, utilization and marketing of Khirni and Amra fruit crop	1
18.	Package of practices, utilization and marketing of Kokum and Kaphal fruit crop	2
19.	Package of practices, utilization and marketing of Cape gooseberry fruit crop	1
20.	Package of practices, utilization and marketing of Persimmon fruit crop	1
21.	Package of practices, utilization and marketing of Pistachio fruit crop	1
22.	Package of practices, utilization and marketing of Hazel nut and other minor fruits of regional importance	2

Practical

S. No.	Topic	No. of Lectures/ Hands on practice
1.	Visits to institutes located in the hot and cold arid regions of the country	**2**
2.	Identification of minor fruits plants/ cultivars	**2**
3.	Collection of leaves and preparation of herbarium	**1**
4.	Generating know-how on reproductive biology of minor fruits	**4**
5.	Fruit quality attributes and biochemical analysis	**3**
6.	Allelopathic studies	**2**
7.	Project formulation for establishing commercial orchards in fragile ecosystems	**1**

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 Arid Horticulture*, Vol. II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.
- Singh *et al*. 2011. *Jamun*. ICAR, New Delhi.

Horticulture (Plantation, Spices, Medicinal and Aromatic Crops)

Production of Plantation Crops **PSMA-501**
Credit Hours: 3(2+1)
Theory:

S. No.	Topics	No. of Lectures
	UNIT-I	
1.	**Role of plantation crops in national economy**	**01**
2.	**Area-production statistics at national and international level**	**01**
3.	**Classification of plantation crops**	**01**
4.	**Clean development mechanism and carbon sequestration potential of plantation crops**	**02**
5.	**Export potential, problems and prospects**	**01**
6.	**IPR issues in plantation crops**	**01**
7.	**Promotional programmes: Role of commodity boards in the developmental programmes of plantation crops**	**02**
8.	**Promotional programmes: Role of directorates in the developmental programmes of plantation crops.**	**01**
	UNIT-II Production Technology of Coconut, Arecanut, Oilpalm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine	
9.	**Production Technology (Varietal wealth: Botany, taxonomy, species, cultivars and improved varieties, Propagation and nursery management: Plant multiplication including in-vitro multiplication, nursery techniques and nursery management, Agro techniques: Systems of cultivation, cropping systems, multitier cropping, climate and soil requirements, systems of planting, high density planting, nutritional requirements, water requirements, fertigation, moisture conservation, role of growth regulators, macro and micro nutrients, nutrient deficiency symptoms, physiological disorders, shade regulation, weed management, training and pruning, crop regulation, plant protection, management of drought, precision farming.) of Coconut**	**02**
10.	**Production Technology of Arecanut**	**02**
11.	**Production Technology of Oilpalm**	**01**
12.	**Production Technology of Cashew**	**01**
13.	**Production Technology of Coffee**	**01**
14.	Production Technology of Tea	02
15.	Production Technology of Cocoa	01
16.	Production Technology of Rubber	01
17.	Production Technology of Palmyrah	01
18.	Production Technology of Betel vine	01
	UNIT-III Harvest and Post-harvest management	
19.	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in Coconut, Arecanut, and Oilpalm	02

20.	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in Cashew, Coffee and Tea	02
21.	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in Cocoa, Rubber, Palmyrah and Betel vine	02
22.	Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of Coconut, Arecanut, and Oilpalm	02
23.	Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of Cashew, Coffee and Tea	02
24.	Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of Cocoa, Rubber, Palmyrah and Betel vine	02

Practical:

S. No.	Topics	No. of Lectures
1.	Description of botanical and varietal features	01
2.	Selection of mother palms and seedlings	01
3.	Nursery techniques	01
4.	Soil and water conservation measures	01
5.	Nutrient deficiency symptoms and Manuring practices	01
6.	Pruning and training methods;	01
7.	Maturity standards and Harvesting;	01
8.	Project preparation for establishing plantations;	01
9.	GAP in plantation crops;	01
10.	Exposure visits to commercial plantations, research institutes.	01

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.
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- 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.

Production of Spice Crops — PSMA-502

Credit Hrs.: 3(2+1)

Theory:

S. No.	Topics	No. of Lectures
	UNIT-I	
1	**Introduction & importance of spice crops – national economy, livelihood, and cultural value**	**01**
2	**Pharmaceutical significance, historical accent, and global trade status**	**01**
3	**Present status of spice crops – national and international scenario**	**01**
4	**Future prospects of spice crops in India & abroad**	**01**
5	**Role of Spices Board and other developmental agencies**	**01**
6	**Classification of spice crops: Major spices, minor spices, seed spices, tree spices, herbal spices. Botany and taxonomy of spice crops**	**02**
7	**Seed propagation methods & nursery techniques Vegetative and micro-propagation methods; nursery management practices**	**01**
	UNIT II Production Technology of Black pepper, Small and large Cardamom, Turmeric, Ginger, Garlic, Coriander, Fenugreek, Cumin, Fennel, Ajwain, Saffron, Vanilla, Nutmeg, Clove, Cinnamon, Allspice, Nigella and Garcinia	
	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.	
8	**Production Technology of Black pepper**	**01**
9	**Production Technology of Small and large Cardamom**	**01**
10	**Production Technology of Turmeric**	**01**
11	**Production Technology of Ginger**	**01**
12	**Production Technology of Garlic**	**01**
13	**Production Technology of Coriander**	**01**
14	**Production Technology of Fenugreek**	**01**

15	Production Technology of Cumin	01
16	Production Technology of Fennel	01
17	Production Technology of Ajwain	01
18	Production Technology of Saffron	01
19	Production Technology of Vanilla	01
20	Production Technology of Nutmeg	01
21	Production Technology of Clove	01
22	Production Technology of Cinnamon	01
23	Production Technology of Allspice	01
24	Production Technology of Nigella	01
25	Production Technology of Garcinia	01
	UNIT III Harvest and Post-harvest management	
26	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting Spice crops	02
27	Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of Spice crops	02

Practical:

S. No.	Topics	No. of Lectures
1	Identification of seeds and plants;	01
2	Botanical description of plant;	01
3	Varietal features;	01
4	Planting material production;	01
5	Field layout and method of planting;	01
6	Cultural practices;	01
7	Harvest maturity, harvesting;	01
8	Drying, storage, packaging;	01
9	Primary processing;	01
10	GAP in spice crops;	01
11	GMP in spice crops;	01

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.
- Gupta S. Ed. Hand Book of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.
- Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford and IBH.
- Nybe EV, Miniraj N and Peter KV. 2007. Spices. New India Publ. Agency.
- Parthasarthy VA, Kandiannan V and 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.

- Ponnuswami V et al. 2018. Medicinal Herbs and Herbal Cure. Narendra Publishing House, New Delhi.
- Pruthi JS. Ed. 1998. Spices and Condiments. National Book Trust.
- Pruthi JS. 2001. Minor Spices and Condiments- Crop Management and Post HarvestTechnology. ICAR.
- Purseglove JW, Brown EG, Green CL and Robbins SRJ. Eds. 1981. Spices. Vols. I, II. Longman. Ramachandra et al. 2018. Breeding of Spices and Plantation 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
- Shanmugavelu KG, Kumar N and Peter KV. 2002. Production Technology of Spices and Plantation Crops. Agrobios.
- Sharangi AB, Datta S and Deb P. 2018. Spices "Agrotechniques for quality produce". Apple Acadamic Press (Tylor and Francis Groups), New Jersey, USA.
- 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 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.

Production of Medicinal and Aromatic Crops — PSMA-503

Credit Hrs.: 3(2+1)

Theory:

S. No.	Topics	No. of Lectures
	UNIT-I	
1.	**Importance of medicinal and aromatic plants, and their role in national economy, utility sectors of different medicinal and aromatic crops**	**01**
2.	**Classification of medicinal and aromatic crops,**	**01**
3.	**Role of institutions, Medicinal Plant Board and NGO's in research and development of medicinal and aromatic crops**	**01**
4.	**Medicinal plant-based industry: Indian system of medicine, traditional systems of medicine, tribal medicine, medicinal industry and the source of medicinal plants**	**01**
5.	**Aromatic plant- based industry: Essential oils, classification, physical and chemical properties and storage of essential oils. Indian perfumery industry,**	**02**
6.	**Area and production of medicinal and aromatic crops, export and import status of major crops, problems, prospects and challenges, IPR issues.**	**01**
	UNIT II	
	Production technology of medicinal crops- Aswagandha, *Andrographis paniculata,* isabgol, opium poppy, safedmusli, *Lepidium sativum, Aloe vera*, sarpagandha, Senna,	

periwinkle, medicinal coleus, glory lily, *Dioscorea* sp., medicinal solanum, *Stevia rebaudiana, Mucuna pruriens, Piper longum, Plumbago zeylanica* and aromatic crops- Palmarosa, lemongrass, citronella, *Ocimum* sp., patchouli, vetiver, mentha, sweet flag, jasmine, geranium, artemisia, lavender and sandal		
7.	**Production technology (Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids, Propagation and nursery management: Seed, vegetative and micro- propagation methods, nursery techniques and nursery management practices 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) of Ashwagandha**	**01**
8.	**Production technology of *Andrographis paniculata***	**01**
9.	**Production technology of isabgol**	**01**
10.	**Production technology of opium poppy**	**01**
11.	**Production technology of safedmusli**	**01**
12.	**Production technology of Palmarosa and lemongrass**	**01**
13.	**Production technology of citronella and *Ocimum* sp.**	**01**
14.	**Production technology of patchouli and vetiver, mentha**	**01**
15.	**Production technology of *Aloe vera***	**01**
16.	Production technology of sarpagandha	01
17.	Production technology of Senna	01
18.	Production technology of periwinkle	01
19.	Production technology of medicinal coleus	01
20.	Production technology of glory lily and *Dioscorea* sp.	01
21.	Production technology of *Lepidium sativum* and medicinal solanum	01
22.	Production technology of *Stevia rebaudiana* and *Mucuna pruriens*	01
23.	Production technology of *Piper longum* and *Plumbago zeylanica*	01
24.	Production technology of sweet flag, jasmine and geranium	01
25.	Production technology of artemisia, lavender and sandal	01
	UNIT III Harvest and Post harvest management	
26.	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in medicinal crops	01
27.	Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in aromatic crops	01
28.	Post harvest management: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in medicinal crops	01
29.	Post harvest management: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in aromatic crops	01

Practical:

S. No.	Topics	No. of Lectures
1.	Description of botanical and varietal features	01
2.	Nursery techniques, Lay out and planting	01

3.	Manuring practices;	01
4.	Maturity standards and Harvesting	01
5.	Primary processing;	01
6.	Extraction of oils;	01
7.	Herbarium preparation;	01
8.	Project preparation for establishing herbal gardens;	01
9.	GAP and GMP in medicinal and aromatic crops;	01
10.	Exposure visits to institutes, herbal gardens and industries.	01

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. 1 Vikaaz Publ.
- Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.
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- 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.

Breeding of Plantation and Spice Crops PSMA -504

Credit Hrs.: 3(2+1)

Theory:

S. No.	Topics	No. of Lectures
Plantation crops: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee, Tea, Palmyrah and Betel vine **Spice crops:** Black pepper, small and large cardamom, Ginger, Turmeric, Fenugreek,		

Coriander, Fennel, Cumin, Ajwain, Garlic, Nutmeg, Cinnamon, Clove and Allspice		
UNIT-I		
1.	**Genetic diversity: Definition, importance and scope in plantation and spice crops**	**1**
2.	**Species and cultivar diversity: cultivated vs. wild relatives and their role in crop improvement.**	**2**
3.	**Cultivar diversity: classification, popular cultivars, and their economic importance.**	**1**
4.	**Floral biology: structure, flowering behaviour, pollination mechanisms. Reproductive biology: fertilization and seed development in plantation & spice crops**	**2**
5.	**Cytogenetics: chromosome behaviour, ploidy levels, and their implications of breeding of plantation & spice crops**	**2**
6.	**Male sterility: types, mechanisms, and applications in hybrid development of plantation & spice crops.**	**1**
7.	**Incompatibility systems: self and cross-incompatibility and their role in breeding of plantation & spice crops.**	**1**
8.	**Germplasm evaluation: survey and collection methods, exploration, and documentation.**	**2**
9.	**Germplasm evaluation: conservation and evaluation – ex situ, in situ conservation, and utilization in breeding programs.**	**2**
UNIT-II		
10.	**Crop improvement: Importance, scope, challenges and limitations in plantation and spice crops**	**1**
11.	**Overview of conventional and modern breeding approaches**	**1**
12.	**Breeding objectives: Breeding objectives/goals on the basis of yield and yield attributes.**	**1**
13.	**Breeding objectives: Breeding objectives/goals on the basis of quality traits.**	**1**
14.	Breeding objectives: Breeding objectives/goals on the basis of stress tolerance to abiotic and abiotic factors.	1
15.	Breeding objectives: Breeding objectives/goals on the basis of wider adaptation in different agro-climates.	1
16.	Breeding methods: Approaches for crop improvement and quality traits, resistance breeding for biotic and abiotic stresses.	1
17.	Breeding Methods: Introduction and Selection	2
18.	Breeding Methods: Hybridization	2
19.	Breeding Methods: Mutation Breeding and Polyploidy Breeding	2
UNIT-III		
20.	Breeding achievements: Breeding achievements in terms of released and popular varieties of plantation and spice crops.	2
21.	Breeding achievements: Breeding achievements in terms of parentage and salient features of released and popular varieties of plantation and spice crops.	2
22.	Future Thrusts: Molecular Breeding and MAS, Role of molecular markers in plantation and spice crops.	2
23.	Future Thrusts: Biotechnological Approaches & Bioinformatics tools	2

Practical:

S. No.	Topics	No. of Lectures
1.	Characterization and evaluation of germplasm;	1
2.	Floral biology, anthesis; pollen behaviour, fruit set;	1
3.	Practices in hybridization, selfing and crossing techniques;	1
4.	Polyploidy breeding;	1
5.	Mutation breeding;	1
6.	Induction of somaclonal variation and screening the variants;	1
7.	Evaluation of biometrical traits and quality traits;	1
8.	Salient features of improved varieties and cultivars;	1
9.	Screening for biotic and abiotic stresses;	1
10.	Exposure visits to research institutes for plantation and spice crops.	1

Suggested Reading

- 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.
- Peter KV. 2002. Plantation Crops. National Book Trust.
- Ramachandra et al. 2018. Breeding of Spices and Plantation crops. Narendra Publishing House, New Delhi.
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- 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.

Breeding of Medicinal and Aromatic Crops PSMA -505

Credit Hrs.: 2(1+1)

Theory:

S. No.	Topics	No. of Lectures
	UNIT I: Genetic diversity:	
	Medicinal crops: Withania somnifera, Papaver somniferum, Plantago ovata, Chlorophytum sp., Rauvolfia serpentina, Aloe vera Cassia angustifolia, Catharanthus roseus, Gloriosa superba, Coleus forskohlii, Stevia rebaudiana, , Piper longum, Plumbago zeylanica. **Aromatic crops:** ocimum, Mint, Geranium, Patchouli, Lemon grass, Palmarosa,	

Citronella, Vetiver, Artemisia and Lavender		
1.	**Species and cultivar diversity: Floral and reproductive biology in M&APs**	**01**
2.	**Cytogenetics, male sterility and incompatibility in M&APs**	**01**
3.	**Wild and cultivated species, popular cultivars in M&APs**	**01**
4.	**Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm in M&APs**	**01**
5.	**IPR issues in M&APs**	**01**
	UNIT II: Crop improvement	
6.	**Breeding objectives: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/ goals on the basis of yield, quality, stress tolerance and adaptation in M&APs**	**02**
7.	Breeding methods: Approaches for crop improvement, introduction, selection, hybridization in M&APs	02
8.	Breeding methods: mutation breeding, polyploidy breeding	01
9.	Improvement of quality traits and resistance breeding for biotic and abiotic stresses in M&APs	01
	UNIT III: Breeding achievements and future thrusts	
10.	Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features in M&APs	02
11.	Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience in M&APs	02

Practical:

S. No.	Topics	No. of Lectures
1	Description of botanical features;	01
2	Cataloguing of cultivars, varieties and species in medicinal and aromatic crops;	01
3	Floral biology, Selfing and crossing	01
4	Evaluation of hybrid progenies;	01
5	Induction of economic mutants;	01
6	High alkaloid and high essential oil mutants;	01
7	Evolution of mutants through physical and chemical mutagens;	01
8	Introduction of polyploidy;	01
9	Screening of plants for biotic and abiotic stress;	01
10	*In-vitro* breeding in medicinal and aromatic crops.	01

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.
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- Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing Agency, New Delhi.

Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops

PSMA-509

Credit Hrs.: 3(2+1)

Theory:

S. No.	Topics	No. of Lectures
	Unit-I Growth, development, assimilate partitioning and plant bio regulators	
1.	**Definition and difference between Growth and development and its components**	**01**
2.	**Photosynthetic productivity, different stages of growth in Plantation, Spice, Medicinal and Aromatic Crops**	**01**
3.	**Growth curves and growth analysis of Plantation, Spice, Medicinal and Aromatic Crops**	**01**
4.	**Morphogenesis in PSMAs**	**01**
5.	**Growth pattern in annual, semi-perennial and perennial crops**	**01**
6.	**Growth dimorphism**	**01**
7.	**Environmental impact on growth and development: effect of light, temperature and photoperiod in PSMAs**	**01**
8.	**Assimilate partitioning during growth and development of PSMAs**	**02**
9.	**Influence of water and mineral nutrition during assimilate partitioning.**	**01**
	Unit-II: Canopy management	
10.	**Canopy management for conventional and high-density planting by applying techniques i.e. training, pruning, chemicals, PGR.**	**02**
11.	**Crop regulation for year-round and off-season production in PSMAs.**	**01**
12.	**Definition, Classification, role and importance of plant growth hormones**	**01**
13.	**Plant bio regulators: auxins basic functions, biosynthesis and role in crop growth and development.**	**02**
14.	Plant bio regulators: gibberellins basic functions, biosynthesis and role in crop growth and development.	01
15.	Plant bio regulators: cytokinin's basic functions, biosynthesis and role in crop growth and development.	01
16.	Plant bio regulators: ethylene basic functions, biosynthesis and role in crop growth and development.	01
17.	Plant bio regulators: inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development.	01

Unit-III: Developmental physiology and biochemistry		
18.	Vegetative phase: Developmental physiology and biochemistry during dormancy in PSMA crops.	01
19.	Developmental physiology and biochemistry during Bud break and juvenility in PSMA crops.	01
20.	Vernalisation, effect of temperature, heat units, thermoperiodism in PSMAs	02
21.	Pollination, fertilization, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.	02
22.	Physiology of flowering and photoperiodism in PSMAs	02
23.	Growth and development process during stress in PSMAs.	02
24.	Production of secondary metabolites during growth and development of PSMAs.	02

Practical:

S. No.	Topics	No. of Lectures
1	Dormancy mechanisms in seeds and seed rhizomes.	01
2	Dormancy mechanisms in buds.	01
3	Techniques of growth analysis.	02
4	Evaluation of photosynthetic efficiency under different environments.	01
5	Technologies for crop regulation in cashew.	01
6	Technologies for crop regulation in coffee.	01
7	Technologies for crop regulation in cocoa.	01
8	Root shoot studies, flower thinning, fruit thinning in PSMAs.	02
9	Crop regulation for year round production in PSMAs.	01
10	Use of growth regulators in PSMA crops.	01

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

Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops
Credit Hrs.: 3(2+1) **PSMA -511**
Theory:

S. No.	Topics	No. of Lectures
UNIT I : Biodiversity: Biodiversity, issues and goals, center of origin of **Plantation, Spice crops, medicinal and aromatic crops,** primary and secondary centers of genetic diversity.		
1.	**Concept of biodiversity, issues, goals and importance in Plantation, Spice crops, Medicinal and Aromatic crops**	**01**
2.	**Center of origin of Plantation crops (coffee, tea, cocoa, coconut, etc.) and Spice crops (black pepper, cardamom, clove, nutmeg, etc.)**	**01**
3.	**Center of origin – Medicinal crops (e.g., *Rauvolfia, Withania, Aloe*, etc.) and Aromatic crops (e.g., mint, lemongrass, basil, etc.)**	**01**
4.	**Biodiversity issues and goals in medicinal and aromatic crops**	**01**
5.	**Primary & secondary centres of genetic diversity – case studies**	**01**
6.	**Concept of biodiversity, issues, goals and importance in horticultural crops**	**01**
UNIT II: Germplasm collection and quarantine		
7.	**Exploration and germplasm collection – principles & methods**	**01**
8.	**Planning, logistics and exchange of germplasm**	**02**
9.	**Plant quarantine principles and Indian quarantine regulations**	**01**
10.	**Germplasm evaluation – components and descriptor lists**	**02**
11.	**Genetic resources conservation: base & active collections, storage methods, gene bank management**	**02**
UNIT III: Documentation and cataloguing		
12.	Biotechnology in PGR conservation, role of in-vitro and cryopreservation	01
13.	Documentation, cataloguing and gene bank information systems	02
14.	Molecular markers in PGR characterization and GIS in biodiversity mapping	01
15.	Genetic resources management of plantation crops in India	01
16.	Genetic resources management of spice crops in India	01
17.	International perspective: treaties, organizations, and achievements in PGR	01
18.	Rarity, threat, endangerment, extinction in **plantation, spice, medicinal and aromatic crops**	04
19.	Biodiversity act, PPV&FRA, DUS testing, geographical indications, international biodiversity regulations	02

Practical:

S. No.	Topics	No. of Lectures
1.	Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources	01
2.	Preparation of herbarium PSMA crop	01
3.	Botanical and phyto-chemical grouping of PSMA crop	01
4.	Classification of PSMA crop based on plant parts used	01

5.	Detection of adulterants and substitutes in PSMAs	01
6.	In-situ preparation of germplasm conservation of PSMA crop	01
8.	Planning and layout of herbal gardens	01
9.	Exposure visits to herbaria, herbal gardens and important organizations engaged in collection and utilization of PSMAs	02

Suggested Reading

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press Choudhari AB. Megadiversity Conservation: Flora, Fauna and Medicinal Plants of India's hot spots.
- Devi AR, Sharangi AB, Acharya SK and Mishra GC. 2017. Coriander in Eastern India: The landraces and genetic diversity. Krishi Sanskriti Publications. New Delhi. ISBN: 978-93-85822-48-3.
- E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
- Kassahun Beemnet, Jemal Omar Sherif, Tessema Tsion, Abate Solomon. 2009. Production, Processing and utilization of Aromatic Plants. EIAR.
- Khan JB and Singh GP. 2012. Biodiversity Management and Conservation LAMBERT Negi SS. Biodiversity of India and its Conservation.
- 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
- 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.
- Panda H. 2017. Herbal and Aromatic Plants Cultivation, Processing, Utilisation and Applications. Discovery publishing house, New Delhi
- Pillay PNR. 1980. Handbook of Natural Rubber Production in India. Rubber Research Institute, Kottayam. pp.668
- Restructured and Revised Syllabi of Post-graduate Programmes Vol. 1
- Ponnuswami et al. 2018. Medicinal Herbs and herbal cure. Narendra Publishing House, New Delhi
- Ponnuswami et al. 2018. Spices. Narendra Publishing House, New Delhi Pullaiah T. 2011. Biodiversity in India Vol.5.Daya Publishing house
- Rajak RC and Rai MK. Herbal Medicines, Biodiversity and Conservation strategies. IBH. Ramakrishnan N. 2018. Biodiversity in Indian Scenario. Daya publishing house.
- 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.
- Thirugnanakumar. 2018. Genetic diversity and phenotypic stability in crop plants. New India Publishing Agency, New Delhi
- Trivedi PC. Medicinal Plants: Utilization and Conservation

Horticulture (Vegetable Science)

Production of Cool Season Vegetable Crops **VSC-501**
Credit Hours:3 (2+1)
Theory:

S. No.	Topic	No. of Lecture
	Unit-I	
1.	**Importance, scope and export potential of cool season vegetable crops**	**2**
2.	**Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil and climate requirements, description of commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods, hydroponics 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 the following crops.**	
3.	**Potato**	**2**
4.	**Garlic**	**2**
5.	**Onion**	**2**
6.	**Cabbage**	**2**
	Unit-II	
7.	**Cauliflower**	**2**
8.	**Kohlrabi**	**1**
9.	**Broccoli**	**1**
10.	**Brussels sprout**	**1**
11.	**kale**	**1**
12.	Carrot	**1**
13.	Radish	**1**
	Unit-III	
14.	Turnip	**1**
15.	Beetroot	**1**
16.	Garden pea	**1**
17.	Bbroad bean	**1**
18.	Beet leaf	**1**
19.	Fenugreek	**1**
20.	Coriander	**1**
21.	Lettuce	**1**

Practical:

S. No.	Topic
1.	Scientific raising of nursery and seed treatment

2.	Sowing and transplanting
3.	Description of commercial varieties and hybrids
4.	Demonstration on methods of irrigation, fertilizers and micronutrients application
5.	Mulching practices, weed management
6.	Use of plant growth substances in cool season vegetable crops
7.	Study of nutritional and physiological disorders
8.	Studies on hydroponics, aeroponics and other soilless culture
9.	Identification of important pest and diseases and their control
10.	Preparation of cropping scheme for commercial farms
11.	Visit to commercial farm, greenhouse/ polyhouses
12.	Visit to vegetable market
13.	Analysis of benefit to cost ratio of vegetable crops

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.

Production of Warm Season Vegetable Crops **VSC-502**

Credit Hours: 3(2+1)

Theory:

S. No.	Topic	No. of Lectures
	Unit I	
1.	**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 for vegetable production.**	**02**
2.	**Seed rate, seed treatment, raising of nursery including grafting technique, sowing/ planting time and methods in Vegetables**	**01**
3.	**Hi-tech nursery management in Vegetables**	**01**
4.	**Modern concepts in nutritional including micronutrients, water and weed management in Vegetables**	**01**
5.	**Physiological basis of growth, yield and quality as influenced by chemicals and growth regulators in Vegetables**	**02**
6.	**Special horticultural practices; hydroponics, aeroponics in Vegetables**	**01**
7.	**Different cropping systems, precision farming and mulching in Vegetables**	**01**
	Unit II	
8.	**Concept of maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.**	**02**
9.	***Production of fruit vegetables*-Tomato, brinjal, hot pepper, sweet pepper and okra.**	**05**
10.	*Production of beans*—French bean, Indian bean (Sem), cluster bean and cowpea.	**03**
	Unit III	
11.	*Production of cucurbits*—Cucumber, melons, gourds, pumpkin and squashes.	**05**
12.	*Production of tuber crops*—Sweet potato, elephant foot yam, tapioca, taro and yam.	**04**
13.	*Production of leafy vegetables*—Amaranth and drumstick.	**02**

Practical

Total Lectures: 15

S. No.	Topic	No. of Lectures
1.	Scientific raising of nursery and seed treatment in vegetables	**01**
2.	Different methods of Sowing, transplanting and vegetable grafting	**01**
3.	Description of commercial varieties and hybrids in Vegetables.	**01**
4.	Demonstration on methods of irrigation, fertilizers and micronutrients application in vegetable crops.	**01**
5.	Mulching practices and weeds management.	**02**
6.	Use of plant growth substances in warm season vegetable crops.	**01**

7.	Study of nutritional and physiological disorders in vegetable crops.	**01**
8.	Studies on hydroponics, aeroponics and other soilless culture in vegetable crops.	**02**
9.	Identification of important pest and diseases and their control in vegetable crops	**01**
10.	Preparation of cropping scheme for commercial farms	**01**
11.	Visit to commercial farm, greenhouse/ polyhouses.	**02**
12.	Analysis of benefit to cost ratio.	**01**

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. 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*. 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.
- 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.

Growth and Development of Vegetable Crops — VSC-503

Credit Hours: 3(2+1)

Theory:

S. No.	Topic	No. of Lectures
	Unit I	
1.	***Introduction and phytohormones*—Definition of growth and development; Cellular structures and their functions; Physiology of**	**04**

	phyto-hormones functioning/ biosynthesis	
2.	**Mode of action; Growth analysis and its importance in vegetable production**	**02**
3.	***Physiology of dormancy and germination*—Physiology of dormancy and germination of vegetable seeds, tubers and bulbs**	**02**
4.	**Role of auxins, gibberellilns, cyktokinins and abscissic acid in vegetable crops**	**02**
	Unit II	
5.	**Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops**	**02**
6.	**Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production**	**03**
7.	*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	**04**
	Unit III	
8.	*Fruit physiology*—Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops;	**03**
9.	Phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening	**03**
10.	*Morphogenesis and tissue culture*—Morphogenesis and tissue culture techniques in vegetable crops	**03**
11.	Grafting techniques in different vegetable crops	**02**

Practical

Total Lectures: 13

S. No.	Topic	Number of Lectures
1.	Preparation of plant growth regulator's solutions and their application on vegetable crops.	**01**
2.	Experiments in breaking and induction of dormancy by chemicals.	**01**
3.	Induction of parthenocarpy and fruit ripening.	**02**
4.	Role of plant growth substances in vegetable crops.	**02**
5.	Application of plant growth substances for improving flower initiation, and checking flower and fruit drops and improving fruit set in solanaceous vegetables.	**03**
6.	Sex expression and modification in cucurbits	**01**
7.	Growth analysis techniques in vegetable crops.	**02**
8.	Visit to commercial vegetable farm	**01**

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.

Principles of Vegetable Breeding — VSC-504

Credit Hours: 3(2+1)

Theory:

S. No.	Topic	No. of Lectures
	Unit I	
1.	***Importance and history*- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.**	**02**
2.	**Recent breeding achievement in vegetable crops.**	**01**
3.	***Selection procedures*- Techniques of selfing and crossing; Breeding systems and methods.**	**03**
4.	**Selection procedures and hybridization in vegetable crops**	**03**
	Unit II	
5.	**Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement in vegetable crops.**	**03**
6.	**Genetic architecture; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).**	**03**
7.	*Heterosis breeding*- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms.	**05**
	Unit III	
8.	*Mutation and Polyploidy breeding*; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.	**04**
9.	*Ideotype breeding*- Ideotype breeding; varietal release procedure.	**02**
10.	DUS testing in vegetable crops.	**01**
11.	Application of In-vitro and molecular techniques in vegetable improvement.	**03**

Practical

S. No.	Topic	No. of Lectures
1.	Floral biology and pollination behaviour of different vegetables.	**01**
2.	Techniques of selfing and crossing of different Solanaceous	**02**

	vegetables, viz., tomato, eggplant, and hot pepper.	
3.	Techniques of selfing and crossing of Cole crops.	**02**
4.	Techniques of selfing and crossing of okra.	**01**
5.	Techniques of selfing and crossing of cucurbits.	**02**
6.	Breeding system and handling of filial generations of different vegetables.	**02**
7.	Exposure to biotechnological lab practices.	**02**
8.	Visit to breeding farms.	**01**

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.

Protected Cultivation of Vegetable Crops — VSC-507

Credit Hours: 3(2+1)

Theory:

Sr. No.	Topic	No. of lecture
	Unit I	
1.	**Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops**	**2**
2.	**Principles, design, orientation of structure, low and high cost polyhouses/ greenhouse structures**	**2**
3.	**Types of protected structure- Classification and types of protected structures- greenhouse/ 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**	**2**
4.	**Hydroponics and aeroponics**	**2**
5.	**Soil and soilless media for bed preparation**	**1**
	Unit II	
6.	**Design and installation of drip irrigation and fertigation system**	**1**
7.	**Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables**	**2**
8.	**Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays**	**2**
9.	**different media for growing nursery under protected cultivation;**	**2**
10.	Nursery problems and management technologies including fertigation	**2**

11.	Regulation of flowering and fruiting in vegetable crops	**1**
12.	**Unit III**	
13.	Cultivation of tomato in protected structures including varieties and hybrids, training, pruning and staking etc.	**2**
14.	Cultivation of sweet paper in protected structures including varieties and hybrids, training, pruning and staking etc.	**2**
15.	Cultivation of cucumber and other vegetables in protected structures including varieties and hybrids, training, pruning and staking etc.	**2**
16.	Problems of growing vegetables in protected structures and their remedies	**2**
17.	Physiological disorders, insect and disease management in protected structures	**2**
18.	Use of protected structures for seed production	**1**
19.	Economics of greenhouse crop production.	**1**

Practical:

Sr. No.	Topic
1.	Study of various types of protected structure
2.	Study of different methods to control temperature, carbon dioxide and light
3.	Study of different types of growing media, training and pruning systems in greenhouse crops
4.	Study of fertigation and nutrient management under protected structures
5.	Study of insect pests and diseases in greenhouse and its control
6.	Use of protected structures in hybrid seed production of vegetables
7.	Economics of protected cultivation (Any one crop)
8.	Visit to established green/ polyhouses/ shade net houses in the region

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.

Production of Underutilized Vegetable Crops **VSC-509**

Credit Hours: 3(2+1)

Theory:

S.No.	Topics	No. of lectures
	Unit I	
1.	**Area, production, economic Importance and export potential of Underutilized vegetable crops.**	**1**
	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 the following crops.	
2	**Asparagus**	**1**
3.	**Leek**	**1**
4.	**Chive**	**1**
5.	**Red cabbage**	**1**
6.	**Cabbage**	**2**
7.	**Kale**	**1**
	Unit II	
8.	**Sweet corn and baby corn**	**2**
9.	**Celery**	**1**
10.	**Parsley**	**1**
11.	**Indian spinach (poi) and Spinach**	**2**
12.	**Chenopods**	**1**
13.	**Chekurmanis**	**1**
14.	Sweet gourd and Spine gourd	2
	Unit III	
15.	Teasle gourd, Round gourd	2
16.	Snake gourd and Pointed gourd,	2
17.	Kachri, Long melon, Snap melon and Gherkin	2
18.	Pointed gourd	2
19	Elephant foot yam	1
20.	Yam bean	1
21	Lima bean	1
22.	Winged bean	1

Practical

S. No.	Topic
1.	Identification and botanical description of plants and varieties;
2.	Seed/ planting material;
3.	Production, lay out and method of planting;
4.	Important cultural operations;
5.	Identification of important pests and diseases and their control;
6.	Maturity standards and harvesting;
7.	Visit to local farms.

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.

Postharvest Management of Vegetable Crops — VSC-514

Credit Hours: 3(2+1)

Theory:

S.No.	Topics	No. of lectures
	Unit I	
1.	**Importance and scope—Importance and scope of post-harvest management of vegetables**	**2**
2.	**Maturity indices and standards for different vegetables**	**2**
3.	**Methods of maturity determination in vegetable crops.**	**2**
4.	**Biochemistry of maturity and ripening; Enzymatic and textural changes**	**2**
5.	**Ethylene evolution and ethylene management in vegetable crops.**	**2**
	Unit II	
6.	**Respiration and transpiration along with their regulation methods.**	**2**
7.	**Preharvest practices and other factors affecting postharvest losses.**	**2**
8.	**Harvesting tools and practices for specific market requirement.**	**2**
9.	Postharvest physical and biochemical changes during ripening of vegetable crops.	2
10.	Packing house operations in vegetable crops	1
	Unit III	
11.	Commodity pre-treatments chemicals, wax coating, pre-cooling and irradiation.	2
12.	Packaging of vegetables, prevention from infestation, management of postharvest diseases.	2
13.	Principles of transportation of vegetables.	1
14.	Methods of storage—Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber.	2
15.	Physiological disorders like chilling injury in vegetables.	2

Practical:

Sr. No.	Topic
1.	Studies on stages and maturing indices;
2.	Ripening of commercially important vegetable crops;

3.	Studies of harvesting, pre-cooling, pre-treatments, physiological disorders-chilling injury;
4.	Improved packaging;
5.	Use of chemicals for ripening and enhancing shelf life of vegetables;
6.	Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release;
7.	Storage of important vegetables;
8.	Cold chain management;
9.	Visit to commercial packinghouse, cold storage and control atmosphere storage.

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. Gene-Tech books, New Delhi.
- Haid NF and Salunkhe SK. 1997. Postharvest physiology and handling of fruits and vegetables. Grenada Publ.
- Mitra SK. 1997. Postharvest physiology and storage of tropical and sub-tropical fruits. CABI.
- Paliyath G, Murr DP, Handa AK and Lurie S. 2008. Postharvest biology and technology of Fruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.
- Ranganna S. 1997. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill.
- Stawley JK. 1998. Postharvest physiology of perishable plant products. CBS publishers.
- Sudheer KP and Indira V. 2007. Postharvest technology of horticultural crops. New India Publ. Agency.
- Verma LR and Joshi VK. 2000. Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
- Willis R, McGlasson WB, Graham D and Joyce D. 1998. Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals. CABI.
- Wills RBH and Golding J. 2016. Postharvest: an introduction to the physiology and handling of fruit and vegetables, CABI Publishing, ISBN 9781786391483.
- Wills RBH and Golding J. 2017. Advances in postharvest fruit and vegetable technology, CRC Press, ISBN 9781138894051.

Syllabus of courses offered for Ph.D. Program in Different Departments

Agronomy

Current trends in Agronomy **Agron-601**

Credit : 3(**3+0)**

Theory:

S. No.	Topics	No. of lectures
	UNIT I	
1.	**Agro-physiological basis of variation in yield,**	2
2.	**Recent advances in soil plant-water relationship**	2
3.	**Globalization of agriculture and WTO**	2
4.	**Precision agriculture, contract farming,**	2
5.	**Organic farming, marketing and export potential of organic products**	1
6.	**Certification, labeling and accreditation procedures**	2
7.	**ITK practices in organic farming**	1
8.	**Crop residue management in multiple cropping systems;**	1
9.	**Latest developments in plant management mechanization in crop production**	2
10.	**Modern agricultural precision tools and technologies**	2
	UNIT II	
11.	**Weed management practices & techniques; novel approaches of weed management in important cropping systems**	2
12.	**Grassland management & agro-forestry**	2
13.	Allelopathy; types, effect on crop growth and interaction with environmental factors	1
14.	GIS, GPS and remote sensing for crop management,	2
15.	Global warming; concept & impact on agriculture and environment, GM crops; issues, development & concerns at global and national platform	2
16.	Concepts of system agriculture; holistic approach of farming systems	3
	UNIT III	
17.	Dryland farming, sustainable agriculture and research methodology in agronomy	2
18.	Seed production technology	2
19.	Seed certification & seed multiplication	2
20.	Hybrid seed production for different crops	2
21.	Conservation agriculture, principles, prospects and importance; Effect of adoption of CA practices on crops and dominant cropping systems	2
22.	Potential benefits of CA under climate change scenario & policy issues	1
	Total	**40**

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: Agroecological Prospectives. 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 Shanker Arun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy 54(2): 226-230.

Recent Trends in Crop Growth and Productivity — Agron-602

Credit : 3(**2+1**)

Theory:

S. No.	Topics	No. of Lectures
	UNIT I	
1.	**Plant density and crop productivity**	1
2.	**Plant and environmental factors**	1
3.	**Yield, plant distribution**	1
4.	**Strategies for maximizing solar energy utilization**	1
5.	**Leaf area**	1
6.	**Interception of solar radiation and crop growth**	1
7.	**Photosynthesis**	1
8.	**Photosynthetic apparatus**	1
9.	**Factors essential for photosynthesis**	1
10.	**Difference in photosynthetic rates among and within species**	1
11.	**Physiological limitations to crop yield**	1
	UNIT II	
12.	**Solar radiation concept and agro-techniques for harvesting solar radiation**	1
13.	**Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and limitations in interpreting crop growth and development**	2
14.	**Growth curves: sigmoid, polynomial and asymptotic**	1
15.	**Root systems; root-shoot relationship**	1
16.	Principles involved in inter and mixed cropping systems under rainfed and irrigated conditions	2

17.	Concept and differentiation of inter and mixed cropping	1
18.	Criteria in assessing the yield advantages	1
19.	Competitive relationship and competition functions	1
20.	Biological and agronomic basis of yield advantage under intercropping	1
	UNIT III	
21.	Physiological principles of dry land crop production, constraints and remedial measures;	1
22.	Heat unit concept of crop maturity:	1
23.	Concept and types of heat units.	1
24.	Concept of plant ideotypes: crop physiological and new ideotypes;	1
25.	Characteristics of ideotype for wheat, rice, maize, etc.;	1
26.	concept and types of growth hormones & their role in field crop production	2
27.	Efficient utilization of resources for sustainable production	1
	Total	**30**

Practicals

Sl. No.	Description
1.	Field measurement of root-shoot relationship in crops at different growth stages
2.	Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
3.	Computation of harvest index of various crops
4.	Assessment of crop yield on the basis of yield attributing characters
5.	Construction of crop growth curves based on growth analysis data
6.	Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
7.	Senescence and abscission indices
8.	Analysis of productivity trend in un-irrigated areas
9.	Analysis of productivity trend in irrigated areas

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.

Irrigation Management **Agron-603**

Credit : 3(**2+1**)

Theory:

S. No.	Topics	No. of lectures
	UNIT I	
1.	**Global water resources; Water resources of India, irrigation projects during pre and post-independence period and their significance in crop production;**	2
2.	**Irrigation needs : definition and factor affecting**	1
3.	**Water deficits and crop growth**	1
4.	**Crop water stress – adaptability to the crops. Water availability with relation to nutrient availability**	2
5.	**Movement of water in soil under saturated and unsaturated conditions,**	1
6.	**Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil**	1
7.	**Soil-plant-water relationships,**	1
8.	**Evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity**	2
9.	**Factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation and optimizing the use of given irrigation supplies**	3
	UNIT II	
10.	**Water requirement and its factor affecting it**	1
11.	**Water use efficiency and management practices for improving water use efficiency of crops**	2
12.	Soil and plant water potential, SPAC (Soil plant atmospheric continuum)	2
13.	Application of irrigation water, conveyance and distribution system	1
14.	Irrigation efficiency; agronomic considerations in the design and operation of irrigation projects;	1
15.	Characteristics of irrigation and farming systems affecting irrigation management	1
	UNIT III	
16.	Strategies of using limited water supply	1
17.	Land suitability for irrigation, land irrigability classification;	1
18.	Integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation	3
19.	Economic analysis of irrigation and cop planning for optimum use of irrigation water	2
20.	Crop water production function	1
	Total	**30**

Practicals

S. No.	Description
1.	Determination of water infiltration characteristics and water holding capacity of soil profiles.
2.	Determination Moisture extraction pattern of crops
3.	Determination of water balance component of transplanted rice by drum culture technique
4.	Determination of consumptive use and water requirement of a given cropping pattern
5.	Determination of crop efficient of one important crop
6.	Planning, designing and installation of drip irrigation system
7.	Planning, designing and installation of sprinkler irrigation system
8.	Designing of drainage channel
9.	Measurement of irrigation efficiencies
10.	Determination of irrigation timing under different methods of irrigation
11.	Visit to irrigation command area

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

Recent trends in weed management — Agron-604

Credit Hrs. :2(**2+0)**

Theory:

S. No.	Topics	No. of lectures
	UNIT I	
1.	**Crop-weed competition in different cropping situations**	1
2.	**Changes in weed flora, various causes and effects**	1
3.	**Different methods of weed management**	3
4.	**Weed Migration, Introduction and adaptation of weeds**	1
5.	**Invasive weeds – biology and management**	1
6.	**Different mechanisms of invasion – present status and factors influencing weed invasion.**	1
7.	**Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action;**	2
8.	**Selectivity of herbicides and factors affecting them.**	1

9.	**Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them,**	2
10.	**Degradation of herbicides in soil and plants-**	1
11.	**Factors affecting degradation of herbicides**	1
	UNIT II	
12.	**Primary and secondary metabolites**	1
13.	**Residue management of herbicides**	1
14.	Adjuvants	1
15.	Advances in herbicide products and application techniques and methods	1
16.	Herbicide resistance	1
17.	Antidotes	1
18.	Crop protection compatibility of herbicides of different groups	1
19.	Compatibility of herbicides with other pesticides	1
20.	Herbicide rotation and herbicide mixtures	1
	UNIT III	
21.	Development of transgenic herbicide resistant crops;	1
22.	Herbicide development, registration procedures.	1
23.	Relationship of herbicides with tillage, fertilizer, and irrigation, Cropping system	1
24.	Bioherbicides	1
25.	Allelochemical and allele herbicide	1
26.	Herbicide bioassays	1
27.	Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film etc.	1
	Total	**31**

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

Research and Publication Ethics **Agron-608**

Credit :2(**2+0**)

Theory:

S. No.	Topics	No. of lectures
	UNIT I	
1.	**Introduction to philosophy: definition, nature and scope, concept, branches**	2
2.	**Ethics: definition, moral philosophy, nature of moral judgements and reactions**	2
3.	**Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity,**	1
4.	**Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data**	3
5.	**Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc.,**	2
6.	**Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship,**	2
	UNIT II	
7.	**Identification of publication misconduct, complaints and appeals, predatorypublishers and journals**	2
8.	Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies;	3
9.	Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.	3
	UNIT III	
10.	Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad.	3
11.	Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools	2
12.	Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc.	2
13.	Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.	3
	Total	**30**

Suggested Reading

- David Smith and Richard Hugman. 1995. Ethical Issues in Social Work (Professional Ethics). 1st edition. Routledge, Taylor & Francis group.
- Nimit Chowdhary and Sarah Hussain. 2021. Handbook of Research and Publication Ethics. Bharti Publications; First Edition pp. 1-252.
- Debabrata Basu, Samarpan Chakraborty, and Aditya Sinha. 2021. Research and Publication Ethics: A Textbook. Concept Publishing Company Pvt. Ltd.; First Edition pp. 1-180.
- Dr. Sumanta Dutta. 2022. Research and Publication Ethics in Social Science. 3rd Edition. Bharti Publications, New Delhi. Pp 1-228.
- Dr. Ajay S. Kushwaha and Dr. Gitanjali J. 2023. Research and Publication Ethics. Das Ganu Prakashan; 1st edition. Pp. 1-195.
- Rashid Manzoor Bhat & Showkat Ahmad Dar. 2023. Research and Publication Ethics: A Comprehensive Guide for Research Scholars. Kitab Writing Publication. Pp. 1-18

Agricultural Economics

Advanced Micro Economic Analysis **AEC-601**
Credit Hrs: 2(1+1)
Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Theory of consumer behavior - Duality in consumer theory - expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect.**	2
2.	**Measurement of Changes in Consumers' Welfare - Consumer's Surplus, Compensating Variation and Equivalent Variation - Dynamic versions of demand functions - Integrability of demand functions.**	2
3.	**Demand Models - Linear Expenditure System, Almost Ideal Demand System.**	1
	Unit-II	
4.	**Applications of consumer theory - Household model and time allocation - Labour supply decisions by households.**	1
5.	**Perfect competition - Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly - Cournot model, Chamberlin model, Stackleberg solution.**	2
6.	General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption.	1
7.	Existence, Uniqueness and Stability of general competitive equilibrium.	1
	Unit-III	
8.	Walrasian general equilibrium - Mathematical derivation of conditions for general equilibrium.	1
9.	Market failure - Incomplete markets - Asymmetric information - Principal-Agent problem, adverse selection and moral hazard.	1
10.	Externalities – Network externalities, Public goods – Optimal provision of public goods.	1
11.	Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics.	1
12.	Pareto conditions of maximum welfare – Criteria for social welfare - Social Welfare functions, Social versus Private costs and benefits.	1

Practical:

S.No.	Topics
1.	Problems in consumer utility maximization
2.	Estimation of income and substitution effects;
3.	Estimation and comparison of Consumer's surplus, equivalent variation and compensating variation.
4.	Estimation of demand models – Derivation and estimation of labour supply

	equations from household models comparative static analysis in consumption.
5.	Advanced problem solving in price determination under perfect competition, monopoly, oligopoly and monopolistic competition.
6.	Game theory models.
7.	Problems solving in General Equilibrium Theory and Welfare Economics.
8.	Problems in public goods provision.

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

Advanced Macro Economic Analysis **AEC-602**
Credit Hrs: 2(2+0)
Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Conceptual framework - Classical, Keynesian, Neo-Classical, and Neo-Keynesian macroeconomics**	2
2.	**Review of Keynes-Classical Synthesis**	1
3.	**Aggregate Demand and Supply in the closed economy with fixed and variable price level- determination of wage, prices, output and employment**	2
4.	**Exchange rate determination**	1
5.	**Purchasing power parity; asset market approach**	1
6.	**Short-run open economy models**	1
7.	**Mundell-Fleming model- exchange rate regime: perfect capital mobility under fixed and flexible exchange rate**	2
	Unit-II	
8.	**Effectiveness of fiscal policy and monetary policy**	1
9.	**Dornbusch's overshooting model**	1
10.	**Monetary approach to balance of payments; international financial markets**	1
11.	Introduction to dynamic macroeconomic Models; Dynamic aggregate demand and supply – short and long term equilibrium- rational expectations approach.	2
12.	Business cycle and its alternative equilibrium model, Stability analysis Economics of Great Events-Depression, Hyperinflation and Deficits	2
13.	Advances in Business Cycle Theory; Real Business Cycles & Neo-Keynesian Economics	1
	Unit-III	
14.	Monetary policy - Design of Monetary Policy; Inflation Targeting, Fiscal Policy	1
15.	Government Budget Constraint: The Arithmetic of Deficits and Debt,	2

	Current versus Future Taxes, the Evolution of Debt-to-GDP Ratio	
16.	Public Borrowing-Internal and external aid, Deficit financing, Development Financing	1
17.	BOP & Adjustment Policies- Foreign Exchange Policy	1
18.	International macro-economic policies, IMF, IBRD, UNCTAD	2

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.

Advanced Econometrics **AEC-603**

Credit Hrs: 3(2+1)

Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Review of classical regression model**	1
2.	**Review of hypothesis testing - restrictions on parameters – single equation techniques.**	2
3.	**Concept of least squares; Ordinary least squares – weighted least squares - generalized least squares.**	3
4.	**Method of principal components**	1
5.	**Iinstrumental variables method, maximum likelihood method**	2
6.	**Errors in variables**	1
	Unit-II	
7.	**Non-linearity and specification tests - non spherical error terms**	2
8.	**Dummy variables**	1
9.	Qualitative and truncated dependent variables - limited dependent variables	2
10.	LPM, probit and logit models, their multinomial extensions.	1
	Unit-III	
11.	Models and theirs extensions- Autoregressive distributed lag models- panel data fixed and random effects models and their extensions.	3
12.	Simultaneous equation methods- Identification	2
13.	Estimation by indirect least squares 2SLS, PIML, SURE, 3SLS	3

Practical:

S.No.	Topics
1.	Estimation of multiple regression model.
2.	GLS estimation methods.
3.	Testing misspecification errors.
4.	Testing and Managing multicollinearity, Heteroscedasticity and autocorrelation
5.	Estimation of LPM, Logit and Probit models
6.	Comparing two regressions - Chow test
7.	Estimation of distributed lag models - panel data random and fixed effects models
8.	Indirect least squares
9.	2SLS, SURE, 3SLS, estimation of simultaneous equation models.

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.

Advanced Production Economics **AEC-604**
Credit Hrs: 3(2+1)
Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Agricultural Production process - Relationship between farm planning and production economics**	1
2.	**Scope of agricultural production and planning-methods/ procedures in agro-economic research and planning**	1
3.	**Production functions, components, assumptions, properties and their economic interpretation.**	1
4.	**Concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance**	1
5.	**Production relations - optimality- Commonly used functional forms, nature, properties, limitations, estimation and interpretation**	1
6.	**linear, Spillman - Cobb Douglas, quadratic, multiplicative (power) functional forms - Translog, and transcendental functional forms - CES, production functional forms**	3
7.	**Conceptual and empirical issues in specification, estimation and application of production functions**	1
	Unit-II	
8.	**Analytical approaches to economic optimum - Economic optimum - determination of economic optimum with constant and varying input and output prices**	2
9.	**Economic optimum with production function analysis - input use behaviour**	1
10.	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	2

11.	Multi input, and multi product production decisions - Decision making with no risk -Cost of wrong decisions	2
12.	Cost curves ‐ Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions	2
	Unit-III	
13.	Technology, input use and factor shares -effect of technology on input use- decomposition analysis-factor shares-estimation methods	1
14.	Economic efficiency in agricultural production ‐ technical, allocative and economic efficiency ‐ measurement	1
15.	Yield gaps analysis ‐ concepts and measurement	1
16.	Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level-risk programming.	1
17.	Simulation and programming techniques in agricultural production-Multiple Objective Programming (MOP)	1
18.	Goal programming, Weighted sum and Compromise programming – applications.	1

Practical:

S.No.	Topics
1.	Estimation of different forms of production functions
2.	Optimal input and product choice from estimated functions.
3.	Derivation of demand and supply functions and estimation
4.	Estimation of cost function and interpretations
5.	Optimal product and input choice under multi input and output system
6.	Estimation of factor shares from empirical functions estimated
7.	Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology
8.	Estimation of efficiency measures
9.	Stochastic, probabilistic and deterministic frontier production functions
10.	Risk programming – MOTAD-Quadratic programming
11.	Simulation models for agricultural production decisions
12.	Goal programming – Weighted, lexicographic and fuzzy goal programming-Compromise programming.

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.

Advanced Agricultural Marketing and Price Analysis **AEC-606**
Credit Hrs: 3(2+1)
Theory

S.No.	Topics	No. of lectures
	Unit-I	
1.	**Insights Importance of market analysis in the agricultural system - types of marketing-advantages and disadvantages**	2
2.	**Qquantitative estimation -the distinguishing characteristics and role of agricultural prices**	1
3.	**Data sources for agricultural products and prices - software used in market analysis**	1
4.	**Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency**	1
5.	**Public - private partnership - institutional arrangements. Successful case studies**	1
6.	**Multi market estimation, supply response models**	2
	Unit-II	
7.	**Market integration and price transmission - supply / value chain management**	1
8.	**GAP analysis**	1
9.	**Current trends in information in the changing agri food system.**	1
10.	**Agricultural commodity marketing -spot and futures**	1
11.	Marketing of derivatives- speculation, hedging, swap, arbitrage etc.	3
12.	commodity exchanges - price discovery and risk management in commodity markets	2
	Unit-III	
13.	Regulatory mechanism of futures trading	1
14.	Lag operators and difference equations	1
15.	Stationary and stochastic processes.	1
16.	Unit roots and co-integration	1
17.	conditional heteroscedasticity: ARCH and GARCH models -forecast evaluation.	2
18.	Methods of forecasting. price indices and econometric estimation and simulation.	2

Practical:

S.No.	Topics
1.	Estimation of demand/ supply forecasting
2.	Supply chain/ value chain analysis for different commodities
3.	Commodity models- multi market estimation- time series analysis
4.	Market integration studies- price discovery price volatility estimation
5.	Commodity price forecasting using econometric softwares.

Suggested Reading

- Acharya SS and Agarawal NL. 1994. Agricultural Prices-Analysis and Policy. Oxford and IBH Publishing company Pvt. Ltd, New Delhi.
- Acharya SS and Agarawal NL. 2004. Agricultural Marketing in India. Oxford and IBH Publishing company Pvt. Ltd, New Delhi.
- Kohls RH and Joseph N. Uhl: Marketing of Agricultural products by Collier MacMillan International.
- Rhodes VJ. 1978. The Agricultural Marketing System. Grid Pub. Ohio.

Agricultural Extension Education

Policy Engagement and Extension **EXT-601**
Credit Hrs.: 3(2+1)
Theory:

S. No.	Description	No. of Lecture
	Unit 1A: Understanding Policy	
1.	**Why policies are important for extension – role in providing structure, funding, and framework with real-world examples**	1
2.	**Policy: Definitions and Types – exploring definitions, types, and whether policy is a product, process, or both**	1
3.	**Policies and Institutions – influence of policies and institutions on organizational roles and performance**	1
4.	**The Role of Policy in Knowledge Upscaling – how policies facilitate dissemination and adoption of knowledge and technologies**	1
5.	**The Role of Extension in Influencing Policies – how extension professionals influence policies for agricultural innovation**	1
	Unit 1B: Policy Advocacy and Tools	
6.	**Definition of Advocacy and Its Approaches – advising, media campaigning, lobbying, and activism**	1
7.	**Information and Communication Tools for Advocacy – use of IEC and BCC in policy advocacy**	1
8.	**Policy Advocacy for Rural Advisory Services (RAS) – strategies and challenges**	1
9.	**Developing a Policy Advocacy Strategy – steps to build a comprehensive strategy**	1
10.	**Case Studies in Policy Advocacy – successful and unsuccessful examples**	1
	Unit 2A: Policy Analysis	
11.	**The Meaning and Use of Policy Analysis – definition and significance**	1
12.	**Types of Policy Analysis – empirical, evaluative, normative, retrospective, prospective, predictive, descriptive**	1
13.	**How to Do Policy Analysis: Process and Methods – steps and techniques**	1
14.	**Ethical Policy Analysis – importance and challenges.**	1
15.	**Tools for Policy Impact – research, context assessment, communication, and influence tools**	1
	Unit 2B: Policy Development Process	1
16.	Who Drives Policy Change – governments, donors, civil society, and their roles	1
17.	Understanding the Environment and Key Actors – stakeholder mapping and problem identification	1
18.	Policy Adoption and Implementation – processes and challenges.	1
19.	Policy Evaluation and Resource Mobilization – evaluation and financial resource strategies	1
20.	Dealing with Policy Incoherence – identifying and addressing	1

	contradictions	
	Unit 3A: Influencing Policy Change	1
21.	Generating Evidence for Policy – role of policy research and evidence	1
22.	Using Evidence and Understanding Your Audience – effective use of evidence and influence channels	1
23.	Alliances and Policy Champions – importance of alliances and champions	1
24.	Developing Advocacy Messages and Materials – goals, objectives, policy briefs, and notes	1
25.	Organizing Policy Dialogues and Engagement – practices for dialogues, panels, and committees	1
	Unit 3B: Global Experience with Extension Policy	1
26.	Extension Policy in Different Countries – comparison of explicit versus integrated policies	1
27.	Challenges in Policy Implementation – capacity, financial, ownership, and consultation issues.	1
28.	Strengthening Capacities to Influence Policies – building extension system capacities	1
29.	GFRAS's Role in Policy Advocacy – compendium and training modules.	1
30.	Using Media and Technology for Policy Influence – ICTs, media, and social media	1

Practicals

Lecture No.	Description
1.	Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS
2.	Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation
3.	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
4.	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
5.	Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use
6.	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.

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

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Bardach E. *A Practical Guide for Policy Analysis The Eightfold Path to More Effective Problem Solving* Fourth Edition. Sage Publications. CQ Press. http://dlib.scu.ac.ir/bitstream/Ebook/32773/2/9781608718429.pdf

Cairney P. 2015. *Chapter 2: Policymaking in the UK: What is Policy and How is it Made? Policy and Policymaking in the UK.*

CRISP, MANAGE and ICAR-ATARI.2016. *Training cum workshop on Strengthening Extension Policy Interface at MANAGE on 9-11th Nov, 2016 in collaboration with the CRISP & ICAR-ATARI, Bangalore*.

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Agriculture and Cooperation, Ministry of Agriculture, Government of India https://sameti.org/Policy%20Framework%20for%20Agricultural%20Extension.pdf

DAFF.n.d. *National Policy on Extension and Advisory Services for Agriculture, Forestry and Fisheries.* Department of Agriculture, Forestry and Fisheries, Republic of South Africa. https://www.daff.gov.za/doaDev/topMenu/National%20Policy.pdf

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Dube L, Nii A Addy, Blouin C and Drager N. 2014**.** *From policy coherence to 21st century convergence: A whole-of-society paradigm of human and economic development.* Annals of the New York Academy of Sciences. 1331: 201–215.

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FAO. 2018. *Policy Guidance Series. Strengthening Sector Policies for Better Food Security and Nutrition Results*. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/publications/policy-guidance-series/en/

FOS. 2006. *Tracking the Impact of Policy Strategies in Conservation Work. Foundations of Success.* Prepared for The Nature Conservancy's Global Conservation Approach Team.

https://www.cbd.int/doc/pa/tools/Tracking%20the%20Impact%20of%20Policy%20 Strategies% 20in%20Conservation%20Work%20.pdf

GFRAS. 2018. *RAS Policy Compendium.* Global Forum for Rural Advisory Services, Switzerland. http://compendium.g-fras.org/

GoI. 2011. *Report of the Working Group on Agricultural Extension for Agriculture and Allied Sectors for the Twelfth Five Year Plan* (2012-17), Section V-Recommendations IV,73-74. http://planningcommission.gov.in/aboutus/committee/wrkgrp12/agri/wg_ agriextn.pdf

GoK. 2012. *National Agricultural Sector Extension Policy (NASEP),* Government of Kenya https://www.kenyamarkets.org/wp-content/uploads/2016/06/National-Agricultural-Sector-Extension-2012.pdf

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IFAD. 2017. *How to incorporate policy engagement into a Country Strategic Opportunities Programme (COSOP)-Country-level policy engagement toolkit.* International Fund for Agricultural Development.
https://www.ifad.org/documents/38714170/39144386/CLPE_HTDN_COSOP_web.pdf/1037e846-dcd3-4c7d-9764-edc08eb4950b

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http://press-files.anu.edu.au/downloads/press/p80991/html/ch03.xhtml?referer=375& page=6

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http://www.g-fras.org/en/component/phocadownload/category/70-new-extensionist-learning- kit-nelk.html?download=664: module-15-policy-advocacy-for-rural-advisory-services- manual5

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Nicholas J Sitko, Babu S, and Hoffman B. 2017. *Practitioner's Guidebook and Toolkit for Agricultural Policy Reform: The P.M.C.A. Approach to Strategic Policy Engagement.* Research Paper 49. Feed the Future Innovation Lab for Food Security Policy. https://www.ifpri.org/cdmref/p15738coll2/id/131127/filename/131338.pdf

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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-

Methodology for Social Sciences and Behavioral Research **EXT-602**
Credit Hrs.: 3(2+1)
Theory

S. No.	Description	No. of Lecture
	Unit 1 (A) **Measurement Properties of Research Instruments**	
1.	**Dimensionality and Validity – concepts of unidimensionality and multidimensionality, internal validity, and assessment methods including judges' ratings and Lawshe's CVR**	1
2.	**External Validity – types (convergent, discriminant, known-group, criterion-related, consequential, nomological) and assessment methods like item-objective congruence index and latent variable method**	1
3.	**Reliability – meaning, types (internal consistency, temporal stability, interrater consistency, alternative forms reliability).**	1
4.	**Factors Affecting Validity and Reliability – factors influencing test scores and introduction to Generalizability Theory**	1
	Unit 1(B) **Threats to Data Quality**	
5.	**Errors in Data Collection – definition, meaning, sources, and types (sampling, non-sampling/measurement, and processing errors)**	1
6.	**Effects of Errors and Biases – impact on data quality and concept of bias in behavioral research**	1
7.	**Types of Biases – respondent and researcher biases**	1
8.	**Reducing Errors and Biases – methods for reducing errors in surveys, questionnaires, interviews, and online data collection**	1
	Unit 1 (C) **Scales, Indexes, and Tests-1**	
9.	**Measurement and Scale Development Approaches – Classical Test Theory, formative models, C-OAR-SE approach, and Item Response Theory**	1
10.	**Item Analysis and Scoring – item difficulty, discrimination, and performance scoring methods**	1
11.	**Scale Development Strategies – deductive and empirical strategies, stimulus-centered scales (equal appearing intervals, paired comparison)**	1
12.	**Person- and Subject-Centered Scales – Q methodology, Likert scale, Semantic Differential**	1
	Unit 2 (A) **Scales, Indexes, and Tests-2**	
13.	**Constructing a Multi-dimensional Scale – steps using confirmatory factor analysis**	1
14.	**Response Scales and Indexes – Guttman's scalogram analysis,**	1

	Rasch method, and introduction to indexes (meaning, types, importance)	
15.	**Similarities and Differences with Scales and Common Indexes – comparison, construction methods, and common indexes in extension**	1
16.	**Measurement Invariance and Tests – meaning, types, assessment methods, and steps in conducting tests such as knowledge tests**	1
	Unit 2(B) **Qualitative Research Methods**	
17.	Qualitative Methods: An Overview – definitions and types (Ethnography, Grounded Theory, Phenomenology).	1
18.	Qualitative Research Designs – observational and case study research, sampling, and sample size.	1
19.	Qualitative Data Collection Methods – in-depth interviews, focus groups, direct observation, record review, content analysis, unobtrusive measures.	1
20.	Qualitative Data Analysis and Synthesis – interpretation, research synthesis, systematic reviews, meta-analysis, and policy research.	1
	Unit 2 (C) **Emerging Approaches**	
21.	Mixed Methods Research – definition, purpose, types, and applications.	1
22.	Participatory and Action Research – meaning, importance, types, applications, and steps in action research.	1
23.	Social Network Analysis – definition, importance, types, steps, and applications.	1
24.	Advanced Methods – methods for measuring perception and beliefs, including multi-criteria decision-making and AHP.	1
	Unit 3(A) **Publishing Research**	
25.	Scholarly Communication and Research Reports – process, meaning, types, and contents.	1
26.	Presentations and Publications – principles of good presentations (Tell 'Em, KISS 'Em) and types of publications.	1
27.	Guidelines for Research Papers – preparation, peer review, and citation styles.	1
28.	Open Access and Social Media – open-access publishing, social media, and academic writing software.	1
	Unit 3(B) **Ethics in Extension Research**	
29.	Ethics in Behavioral Research – importance, history, and ethical guidelines for human subjects.	1
30.	Ethical Aspects of Indigenous Knowledge – collection and use of Indigenous knowledge and farmers' technologies.	1
31.	Ethical Practices in Publishing – plagiarism, meaning, and sources.	1
32.	Identifying and Correcting Plagiarism – detection methods and anti-plagiarism software.	1

Practical

S. No.	Description
1.	Practice in developing research instruments
2.	Methods of assessing measurement properties of research instruments -
3.	dimensionality, reliability and validity
4.	Hands-on exercise in minimising errors and biases
5.	Hands-on experience in constructing tests, scale and indexes
6.	Practice in summated scale development using confirmatory factor analysis
7.	Hands on experience in assessing measurement invariance
8.	Practicing and collecting data using participatory tools and techniques, analyzing
9.	and interpreting qualitative data
10.	Hands-on experience in writing systematic review using meta-analysis
11.	Field practice in conducting action research
12.	Practical experience in writing research paper
13.	Hands on exercises using software for qualitative data analysis
14.	Practice in detecting and correcting plagiarism using software

Suggested Reading

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Creswell JW .2007. *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: SAGE Pub.

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Netemeyer RG, Bearden WO and Sharma S. 2003. *Scaling procedures: issues and applications.* Thousand Oaks: SAGE Publications.

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Technology Commercialization and Incubation **EXT-603**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	**Basics of technology commercialisation-Technology - Definition, functions, process of technological advancement – invention, discovery, innovation and technology**	**1**
2.	**Types of innovation - Basic research, Breakthrough innovation, Disruptive Innovation and Sustaining Innovation; Technology transfer and commercialization.**	**1**
3.	**Agricultural technology – meaning, types; technology generation system; technology life cycle**	**1**
4.	**Technology transfer Vs Commercialisation; Technology commercialisation process – elements, models, systems and processes**	**1**
5.	**Technology transfer model – research, disclosure, development and commercialisation**	**1**
6.	**Introduction to IPR; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design**	**1**
7.	**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**	**1**
8.	**IPR protection laws and systems – National IPR Policy; and IPR laws; procedures for filing IP protection**	**1**
9.	**Systems of IP protection and management in agricultural universities and research institutions and also by stakeholders**	**1**
10.	**Mechanisms of IPR Management – Institutional arrangement, IP Management processes – invention disclosure**	**1**
11.	**Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for registration and transfer of biological resource**	**1**
12.	**Farmers rights; Mechanisms of documenting/ collecting, protecting and commercialising farmers varieties and other biological resources**	**1**
13.	**National Biodiversity Authority, PPVFRA and other agencies involved in management of biological resources in India. Access to Genetic Resources and Sharing of Benefits**	**1**
	UNIT-II	
14.	**Traditional and Indigenous Knowledge, Grassroot and Farmers Innovations – Meaning, forms and importance; Systems of documentation, registration, protection and commercialisation**	**1**
15.	**Documentation of traditional indigenous knowledge - Traditional Knowledge Digital Library (TKDL), Community Biodiversity Registers (CBRs), People's Biodiversity Registers (PBRs), Plant**	**1**

	Biodiversity Register, and Honeybee Network.	
16.	**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**	**1**
17.	The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety	**1**
18.	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)	**1**
19.	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	**1**
20.	Meaning; Importance; Approaches and methods of assessment and refinement of various technologies – stakeholder-oriented approaches including participatory technology assessment and refinement	**1**
21.	Assessment and refinement of traditional and indigenous knowledge and grassroot innovations	
22.	Returns to investment; IP Valuation-Oxford context, IP Valuation methods - Cost approach	**1**
23.	Income approach - Discounted Cash Flow, Risk-Adjusted Net Present Value, Net Present Value with Monte Carlo Simulation and Real Options Theory	**1**
24.	Market approach - Industry Standards Method, Rating/Ranking Method, Rules of Thumb Approach and Auction Method; Hybrid approaches; Royalty rate method	**1**
25.	Technology commercialisation -Meaning and approaches, technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation	**1**
26.	Meaning, types and stages of technology scaling up; mechanisms, Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process	**1**
	UNIT-III	
27.	Technology Takers and Entrepreneurship -Meaning and types; Technology Taking as a Strategy; Types of entrepreneurships – agripreneur, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms of entrepreneurship	**1**
28.	Policy support for entrepreneurship development in India- 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	**1**
29.	Meaning, functions and types; stakeholder-oriented incubation process – Livelihood incubation, village incubators	**1**

30.	System of technology incubation- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India	**1**
31.	Technology promotion – meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers fairs, technology shows	**1**
32.	Business communication; Business Etiquette; business networking, Technology Scouting and Innovations in technology incubation	**1**

Practicals

S. No.	Description
1.	Understanding the technology commercialisation process – Visit to Technology Commercialisation Unit of ICAR Institute/ Agricultural University
2.	Understanding the IPR protection practices – Visit to Patent Attorney office
3.	Hands-on experience in drafting IPR application – Patent/Copyright/ Trademark
4.	Understanding protection of biological resources including plant varieties – Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection
5.	Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge
6.	Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications
7.	Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods
8.	Hands on experience in technology evaluation
9.	Hands on experience in technology licensing process including drafting agreements
10.	Understanding the Technology Business Incubation – Visit to Agri Business Incubator or Technology Business incubator
11.	Hands on experience in planning and organising technology promotion events
12.	Hands on experience in various techniques in business communication and Business etiquette

Suggested Reading

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Ghosh, S. and Joshi, A. 2017. Handbook for Non-Profit Incubator Managers. New Delhi: Deutsche Gesellschaftfür Internationale.

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World Intellectual Property Organization (WIPO).

Educational Technology and Instructional Design **EXT-604**

Credit Hrs: 3(2+1)

Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	**Understanding various terms - educational technology, instructional design, instructional systems design, curriculum design, pedagogy, andragogy**	**1**
2.	**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**	**1**
3.	**Extensional professionals as instructional designers and architects of the learning experience**	**1**
4.	**What is learning? Critical overview of Behaviourism, Cognitivism, Constructivism and Complex learning theories; Instructional designers and learning theories**	**1**
5.	**Types of learning or learning domains- Bloom's taxonomy of the cognitive domain**	**1**
6.	**Krathwohl and Bloom's affective domain and Simpson's psychomotor domain**	**1**
7.	**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**	**1**
8.	**elearning, Massive Open Online Courses - SWAYAM, Open Education Resources (OERs), Course CERA, eduex, col, rlos; digital education and its applications in higher agricultural education**	**1**
9.	**Smart classrooms and Campuses, Web-based remote laboratory (WBRL); Integrating media and digital tools into ID;**	**1**
10.	**Types and implications of disruptive technologies for higher education and extension**	**1**
11.	**Augmented learning; Adaptive learning; meaning, features and good practices in using open-source Learning Management Systems (Moodle);.**	**1**
12.	**Quality assurance and certification in e-learning**	**1**
	UNIT-II	
13.	**Theories and Models of Instruction- Howard Gardner's Theory of Multiple Intelligences,**	**1**
14.	**David Kolb's Experiential Learning Cycle, Albert Bandura's Social Learning Theory, Rand Spiro's Cognitive Flexibility**	**1**

	Theory and Its Application In eLearning,	
15.	**Wlodkowski's Motivational Framework for Culturally Responsive Adult Learning; ADDIE Model, Dick and Carey Model, SAM Model, Bloom's Taxonomy;**	**1**
16.	**Integrating the theories of instruction into the practice of ID in extension and RAS ecosystem**	**1**
17.	Overview of planning, designing and implementing the curricula and learning experiences; Needs Analysis - meaning, approaches and steps	**1**
18.	Task and content analysis - meaning, approaches, steps and techniques (topic analysis, procedural analysis, and the critical incident method)	**1**
19.	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	**1**
20.	Learning Objectives; abcds of well-stated objectives; Setting goals, translating goals into objectives	**1**
21.	Contextualising ADDIE process within the Extension learning environment	**1**
22.	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	**1**
23.	Gagne's events of instruction, Edgar Dale's Cone of Experience; Methods of Delivery- classroom teaching, programmed instruction,	**1**
24.	Synchronous and asynchronous modes of distance education, Changing role of a teacher in classroom and teaching competencies	
	UNIT-III	
25.	Meaning of Assessment, Measurement and Evaluation; Developing learner evaluations and their reliability & validity	**1**
26.	Assessment techniques for measuring change in knowledge, skill and attitude of learners - Objective Test Items, Constructed-Response Tests, Direct Testing	**1**
27.	Performance Ratings, Observations and Anecdotal Records, Rubrics, Portfolios, Surveys and Questionnaires, Self- Reporting Inventories, Interviews	**1**
28.	Conducting learner evaluation pre-, during and post-instruction; Formative and Summative Evaluation- meaning, approaches and steps	**1**
29.	Evaluating Learner Achievement and the Instructional Design Process; Evaluating the success of instruction; Performance appraisal of teachers	**1**
30.	Alternatives to ADDIE model - Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art	**1**
31.	Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries;	**1**

32.	University assessment and rating methods, returns from agricultural higher education; research in education and instructional design.	**1**

Practicals

S. No.	Description
1.	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
2.	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
3.	Assessing learning styles through Barsch and Kolb inventories
4.	Development and testing of survey instruments for evaluating learning outcomes/ competencies of students
5.	Development and testing of survey instruments for performance appraisal / competency assessment of teachers.
6.	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
7.	Designing and developing a theme-based knowledge portal
8.	Exercises on designing an online course using open source LMS like moodle or EdX
9.	Select and evaluate or design for social al media
10.	Prepare a short research paper on recent theories and models of instructional design
11.	Interview an instructional designer of your choice and prepare a synthesis report about what job roles he/she performs, What ID processes does he or she use, challenges faced
12.	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
13.	Field visit to a virtual learning / augmented learning lab, e-learning labs, distance learning centres, etc.
14.	Hands-on practice with video-editing software, web conferencing and video conferencing solutions

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 Experiences

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Kolb D. 2014. Experiential learning: Experience as the source of learning and development (2nd ed.). Upper Saddle River, NJ: Prentice Hall

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Reiser RA. 2001. A History of Instructional Design and Technology: Part I: A History of Instructional Media. Educational Technology Research and Development, 49 (1), 53-64.

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Enhancing adult motivation-Bokos-Z1-.pdf

Websites

e-Learning Industry– https://elearningindustry.com/

InstructionalDesignCentral https://www.instructionaldesigncentral.com/ Instructional Design– http://www.instructionaldesign.org/theories/ International Society for Educational Technology– https://www.isfet.org/courses/ Educational Technology– https://educationaltechnology.net/

AESA-Agricultural Extension in South Asia– http://www.aesanetwork.org/ GFRAS-Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

Facilitation for People Centric Development **EXT-607**
Credit Hrs: 3(2+1)
Theory:

S.No.	Topics	No. of lectures
	UNIT-I	
1.	**Facilitation for development in the AIS; Understanding facilitation for development**	1
2.	**Importance of facilitation as a core function of extension within the Agricultural Innovation Systems (AIS)**	1
3.	**Basic principles of facilitation for development**	1
4.	**Desired attributes of facilitator for development- Cognitive attributes**	1
5.	**Emotional attributes (Emotional intelligence), Social, behavioural and attitudinal attributes**	1

6.	**Technical skills of a facilitator for development- Design processes, Facilitation techniques and tools**	1
7.	**Art of questioning and probing, Process observation and documentation, Visualization**	1
8.	**Realise Potential- Self-discovery to realise our potentials,**	1
9.	**Tools for self-discovery**	1
10.	**Formulating a personal vision, Taking responsibility for your own development**	1
	UNIT-II	
11.	**Understanding the dynamics of human interaction, Group dynamics and power relations**	1
12.	**Managing relationships, Shared vision and collective action, Tools for team building**	1
13.	**Organizational change process, Organizational learning to adapt to changing environments**	1
14.	**Enhancing performance of organizations**	1
15.	Leadership development, Tools for organizational change	1
16.	Defining stakeholders, Development of collective and shared goals	1
17.	Building trust and accountability, Tools for stakeholder identification and visioning	1
18.	Visualising innovation platforms (ips), Why are ips important	1
19.	Different models of ips for multi-stakeholder engagement	1
20.	Policy engagement platforms, Generating issues and evidence for policy action, Advocacy for responsive policy processes	1
	UNIT-III	
21.	Brokering linkages and strategic partnerships, Identification of critical links	1
22.	Knowledge brokering, Creating linkages with markets	1
23.	Learning alliances and networking	1
24.	Coordination of pluralistic service provision within the AIS	1
25.	The concept of action learning and reflective practitioners, Networking	1
26.	Facilitating Capacity Development-Facilitate participation and learning in development programs and projects	1
27.	Virtual platforms- skills for strengthening dialogue, collaboration, shared commitment amongst diverse actors and stakeholders	1

Practicals

S. No.	Description
1.	Practicing facilitation techniques,
2.	Self-discovery exercises,
3.	Working together and interaction (task based),
4.	Arrangement for multi-stakeholder interactions,
5.	Understanding organisational change process tools and techniques,
6.	Case analysis on organisational change process,
7.	Participating with innovation platforms,
8.	Policy engagement platforms,

9.	Stakeholder analysis mapping,
10.	Exercise on networking skills,
11.	Facilitating capacity building programmes
12.	Facilitating virtual platforms
13.	Field visit to multi-stakeholder partnership projects

Suggested Reading

Anonymous. Seeds for Change. Facilitation Tools for Meetings and Workshops. Available https:/ /seedsforchange.org.uk/tools.pdf

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Websites

MSU–Michigan State University Extension Facilitation– https://www.canr.msu.edu/facilitation/

TAPipedia– Tropical Agriculture Platform– https://www.tapipedia.org/

CGSpace- A Repository of Agricultural Research Outputs by CGIAR– https://cgspace.cgiar.org/handle/10568/33667

UMaine– The University of Maine– https://extension.umaine.edu/community/strengthening-your-facilitation-skills/

GFRAS– Global Forum for Rural Advisory Services– http://www.g-fras.org/en/

Entomology

Insect Phylogeny and Systematics **ENT- 601**
Credit Hrs: 3(1+2)
Theory:

S. No.	Topic	No. of Lectures
	Unit -I	
1.	**Insect phylogeny: Definition, introduction & evolutionary history Systematics: Definition, aims, components, principles and its importance**	**1**
2.	**Detailed study of three schools of classification - Numerical, Evolutionary and Cladistic**	**1**
3.	**Methodologies employed; Development of phenograms & cladograms**	**1**
4.	**Molecular phylogeny: Definition, molecular approaches for the classification of organisms; Identification: Definition & methods in identification of homology**	**1**
5.	**Species: Definition, species concepts and types; Speciation: Definition, processes and evidences and type of speciation; Zoogeography**	**1**
6.	**Study of different views on the evolution of insects- alternative phylogenies of insects Kukalova Peck and Kristensen**	**2**
7.	**Fossil insects & Evolution of insect diversity over geological times**	**1**
	Unit -II	
8	**Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; Scientific ethics**	**1**
9.	**Zoological nomenclature: Introduction, definition, history, principles, objectives, rules, scope and importance and documentation protocols and procedures**	**2**
10.	Report preparation on new species	1
11.	Deposition of holotypes, paratypes and insect specimens as a whole in national and international repositories – requirements and procedures.	2
12.	Phylocode: Concept of Phylocode, principles & alternative naming systems for animals	2
	Unit -III	
13.	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.	3
14.	Websites related to insect taxonomy and databases	2
15.	Molecular taxonomy: Definition, introduction and its importance	1
16.	Barcoding species and the progress made in molecular sytematics	1

Practical:

S. No.	Topic
1.	Collection and curation of insect species
2.	Study of one taxon of insects- literature search, compilation of a checklist,

3.	Study of characters, development of character table
4.	Construction of taxonomic keys for the selected group
5.	Development of descriptions, photographing, writing diagrams
6.	Preparation of specimens for "type like" preservation,
7.	Submission of the collections made of the group
8.	Multivariate analysis techniques for clustering specimens into different taxa
9.	Development of phenograms
10.	Rooting and character polarization for developing cladograms
11.	Use of computer programmes to develop cladograms

Suggested Reading

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- Dakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology.* Springer-Verlag, Berlin.
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Insect Physiology and Nutrition — ENT- 602

Credit Hrs: 3(2+1)

Theory:

S. No.	Topic	No. of lectures
	Unit -I	
1.	**Physiology: Definition, braches, scope and importance of insect**	**1**
2.	**Physiology and biochemistry of insect cuticle; type of cuticle; cuticular growth**	**1**
3.	**Moulting: Definition, moulting process and hormonal control**	**1**
4.	**Biosynthesis of chitin, process and inhibitors of chitin synthesis**	**1**
5.	**Chitin-protein interactions in various cuticles**	**1**
6.	**Hardening process of cuticle and hormones involved cuticle production**	**1**
7.	**Detailed physiology of digestive in phytophagous**	**1**
8.	**Enzymes involve in various type of digestive**	**1**
9.	**Digestive physiology in wood boring and wool feeding insects**	**1**
10.	**Microbes in digestion**	**1**
11.	**Efficiency of digestion and absorption**	**1**
12.	**Role of endosymbionts in insect nutrition**	**1**
	Unit -II	

13.	**Nutritional effects on growth and development in phytophagous**	**1**
14.	**Detailed physiology of excretion and osmoregulation**	**1**
15.	**Water conservation mechanisms**	**1**
16.	Detailed physiology of nervous system	1
17.	Transmission of nerve impulses; Neuro-transmitters & modulators	1
18.	Production of receptor potentials in different types of sensilla, pheromones	1
19.	Semio-chemicals: Definition, role & types of semio-chemicals in insect life	1
20.	Toxins: Definition, role of toxin in insect life	1
21.	Detailed defense mechanisms in insects	1
	Unit -III	
22.	Glandular endocrine system and insect hormones	1
23.	Physiology of insect growth and development metamorphosis	1
24.	Polymorphism in insects	1
25.	Diapauses: Definition, types and various stages in insects; factor affecting of diapause	1
26.	Insect behaviour in IPM- Concept of super-normal stimuli	1
27.	Behavioural manipulation as potential tool in pest management	1
28.	Use of semio-chemicals	1
29.	Auditory stimuli signals in pest management	1
30.	Visual signals in pest management	1

Practical:

S. No.	Topic
1.	Preparation of synthetic diets for different groups of insects
2.	Rearing of insects on synthetic, semi-synthetic and natural diets
3.	Determination of co-efficient of utilization
4.	Qualitative and quantitative profile of bio-molecules
5.	Practicing analytical techniques for analysis of free amino acids of haemolymph
6.	Zymogram analyses of amylase
7.	Determination of chitin in insect cuticle
8.	Examination and count of insect haemocytes

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.

Insect Ecology and Diversity **ENT- 603**

Credit Hrs: 3(2+1)

Theory:

S. No.	Topic	No. of lectures
	Unit -I	
1.	**Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography.**	**1**
2.	**Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections.**	**2**
3.	**Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.**	**2**
4.	**Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations.**	**2**
5.	**Role of insects in the environment. Adaptations to terrestrial habitats.**	**2**
	Unit -II	
6.	**Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants.**	**2**
7.	**Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites.**	**2**
8.	Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.	2
9.	Biodiversity and Conservation- RET species, Ecological Indicators.	1
10.	Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection.	2
	Unit -III	
11.	Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.	2
12.	Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict.	3
13.	Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.	2

Practical:

S. No.	Topic
1.	Methods of data collection under field conditions;
2.	Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc.;
3.	Calculation of sample sizes by different methods;

4.	Fitting Poisson and Negative Binomial distributions and working out the data transformation methods;
5.	Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift;
6.	Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/ *Goniozus*/ Female Bruchids, etc.;
7.	A test of reproductive effort and fitness;
8.	Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution;
9.	Exercises in development of Algorithms for crop modeling;

Suggested Reading

- Barbosa P and Letourneau DK. (Eds.). 1988. *Novel Aspects of Insect-Plant Interactions*. Wiley, London.
- Elizabeth BA and Chapman RF. 1994. *Host-Plant Selection by Phytophagous Insects.* Chapman and Hall, New York.
- Freeman S and Herron JC.1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.
- Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Sunderland, MA.
- Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
- Krebs C. 1998. *Ecological Methodology.* 2nd Ed. Benjamin-Cummings Publ. Co., New York. Krebs CJ. 2001 *Ecology: The Experimental Analysis of Distribution and Abundance*. 5th Ed.
- Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. *Ecological Diversity and its Measurement.* Princeton University Press, Princeton.
- Real LA and Brown JH. (Eds.). 1991. *Foundations of Ecology: Classic Papers with Commentaries.*
- University of Chicago Press, USA.
- Southwood TRE and Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Wiley Blackwell, London. Strong DR, Lawton JH and Southwood R. 1984. *Insects on Plants: Community Patterns and*
- *Mechanism*. Harward University Press, Harward.
- Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold Publ., London.

Bio-inputs for Pest Management — ENT- 605

Credit Hrs: 3(2+1)

Theory:

S. No.	Topic	No. of lectures
	Unit -I	
1.	**Bio-inputs: Definition and its components; advantages and disadvantages of bio-inputs**	**1**
2.	**Classical biological control: Definition, principles, history development, scope and importance of classical biological control**	**1**
3.	**Augmentative bio-control: Definition, kinds of augmentation**	**1**

4.	**Introduction and handling process of natural enemies**	**1**
5.	**Nutrition of entomophagous insects and their hosts**	**1**
6	**Dynamics of bio-agents *vis-à-vis* target pest populations like-predators, parasites and parasitoids and its types**	**2**
7.	**Bio-inputs: Mass production of bio-pesticides: Botanical biopesticides**	**1**
8.	**Mass production of fungal microbial biopesticides**	**1**
9.	**Mass production of bacterial microbial biopesticides**	**1**
10.	**Mass production of viral microbial biopesticides**	**1**
	Unit -II	
11.	**Mass production of nematodes, protozoa & rickettes microbial biopesticides**	**2**
12.	**Mass culturing techniques of bio-agents like major predators**	**2**
13.	Mass culturing techniques of bio-agents like major parasitoids	2
14.	Insectary: Definition, basic standards of insectary, insectary facilities and equipments, viable mass-production unit, designs, Precautions, good insectary practices	1
15.	Colonization of NEs: Definition, introduction and factors	1
16.	Techniques of release of natural enemies	1
17.	Recovery evaluation of NEs: Methods and techniques	1
18.	Conservation of NEs: Methods and practices of conservation of NEs	1
	Unit -III	
19.	Augmentation of NEs: Definition, introduction and its types	1
20.	Survivorship analysis of NEs: Introduction and methods	1
21.	Ecological manipulations: Definition, introduction and techniques	1
22.	Large-scale production of bio-control agents; Bankable project preparation	2
23.	Genetic engineering: Definition, Scope and importance of genetically engineered microbes and parasitoids in biological control	2
24.	Genetics of ideal traits in bio-control agents for introgressing and for progeny selections	2
25.	Breeding techniques of bio-control agents	1

Practical:

S. No.	Topic
1.	Mass rearing and release of some commonly occurring indigenous natural enemies
2.	Assessment of role of natural enemies in reducing pest populations
3.	Testing side effects of pesticides on natural enemies of predators
4.	Testing side effects of pesticides on natural enemies of parasitoids
5.	Effect of semio-chemicals on natural enemies
6.	Breeding of various bio-control agents
7.	Performance of efficiency analyses on target pests
8.	Project document preparation for establishing a viable mass-production unit/insectary
9.	Observation of feeding behavior acts of predatory bugs
10.	Observation of feeding behavior acts of predatory beetles

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.

Insect Toxicology and Residues ENT- 606

Credit Hrs: 3(2+1)

Theory:

S. No.	Topic	No. of lectures
	Unit -I	
1.	**Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides**	**2**
2.	**Modes of action of newer insecticide molecules**	**3**
3.	**Developments in bio-rational approaches; SPLAT; RNAi technology for pest management**	**2**
4.	**Biochemical and physiological target sites of insecticides in insects**	**2**
	Unit -II	
5.	**Developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides**	**3**
6	Joint action of insecticides; activation, synergism and potentiation	2
7.	Problems associated with pesticide use in agriculture	1
8.	Pesticide resistance; resistance mechanisms and resistant management strategies	1
9.	Pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects	2
	Unit -III	
10.	Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods	3
11.	Maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility	2
12.	Insecticide laws and standards, and good agricultural practices	2

Practical:

S. No.	Topic	
1.	Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods;	3

2.	Calculations and interpretation of data;	2
3.	Biochemical and biological techniques for detection of insecticide resistance in insects;	2
4.	Preparation of EC formulation using neem oil.	2

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.
- 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.

Plant Resistance to Insects — ENT-607

Credit Hrs.: 2(1+1)

Theory

S. No.	Topic	No. of lectures
	Unit -I	
1.	**Importance of plant resistance, historical perspective**	**1**
2.	**Desirable morphological and anatomical adaptations of resistance**	**1**
3.	**Desirable biochemical adaptations of resistance**	**1**
4.	**Assembly of plant species – gene pool**	**1**
5.	**Insect sources – behaviour in relation to host plant factors.**	**1**
	Unit II	
6.	**Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance**	**2**
7.	Biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways	2
8.	Effects of induced resistance; exogenous application of elicitors.	1
	Unit III	
9.	Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances	1
10.	Incorporation of resistant gene in crop varieties; marker- aided selection in resistance breeding.	1

11.	Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses	1
12.	Techniques and determination of categories of plant resistance	1
13.	Breakdown of resistance in crop varieties	1

Practical:

S. No.	Topic	
1.	Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance;	2
2.	Macroculturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests;	2
3.	Field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries;	2
4.	Determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.	2

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.

Genetics and Plant Breeding

Advances in Plant Breeding Systems **GPB-601**
Credit Hrs.: 3(3+0)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Advances in reproductive biology of crops – importance and applications**	1
2.	**Genes governing floral whorl formation – ABC model; Extended models of floral development – ABCE, quartet model**	1
3.	**Pollen–pistil interaction: biochemical basis; Pollen–pistil interaction: molecular basis and signaling**	2
4	**Environmental control of anthesis; bottlenecks for gene transfer**	1
5.	**Classical breeding methods – overview; Pre-Mendelian contributions to crop improvement**	2
6.	**Mendelian breeding systems in self-pollinated crops**	1
7.	**Post-Mendelian methods in cross-pollinated crops**	1
8.	**Molecular and transgenic breeding – concepts**	1
9.	**Doubled haploid breeding – techniques and applications**	1
10.	**Shuttle breeding – concept and case studies; Forward and reverse breeding; speed breeding**	1
11.	**Participatory and organic breeding approaches**	1
	Unit-II	
12.	**Principles of forming complex populations**	1
13.	**Genetic basis of population improvement**	1
14.	**Recurrent selection in self-pollinated crops; Recurrent selection in cross-pollinated crops**	1
15.	**Modifications of recurrent selection methods; Convergent and divergent selection strategies**	1
16.	**Reciprocal recurrent selection and its applications**	1
17.	**Selection strategies in clonally propagated crops**	1
18.	**Choice of molecular markers for breeding efficiency**	1
19.	**Fingerprinting and genetic purity testing**	1
20.	**Genetic diversity analysis using molecular tools**	1
21.	**MAS for qualitative traits**	1
22.	**MAS for quantitative traits – QTL applications**	2
23.	**Gene pyramiding and accelerated backcrossing**	1
24.	**Marker-assisted introgression and exotic germplasm utilization**	1
	Unit-III	
25.	Genetic resources: primary, secondary, tertiary, and alien gene pools	1
26.	Self-incompatibility – molecular and biochemical basis	1
27.	Gametophytic and sporophytic SI mechanisms	1
28.	Male sterility – genetic and biochemical basis	1
29.	Nucleocytoplasmic interactions in sterility	1
30.	Genetic engineering for creating male sterility; Prospects and challenges	1

	of engineered male sterility	
31.	Fertility restoration in male sterile lines; Restorer diversification strategies; Conversion of elite genotypes into sterile systems; Conversion of elite genotypes into sterile systems	2
32.	Cyto-nuclear interactions: case studies	1
33.	Stability of male sterile lines under environmental influences	1
34.	Apomixis – types, mechanisms and genetic basis; Applications of apomixis in heterosis breeding	2
35.	Incongruity in wide crosses – causes; Methods to overcome incongruity – conventional; Molecular and biotechnological methods to overcome incongruity	2
36.	Integration of apomixis, sterility and incongruity management	1
37.	Breeding for improved root systems and drought tolerance	2
38.	Breeding for water-use efficiency, flooding and submergence tolerance	2
39.	Breeding for heat, cold, and multiple abiotic stress tolerance	2
40	Breeding for biotic stress tolerance under climate variability	2
41.	Nutrient-use efficiency, nitrogen fixation and assimilation	1
42.	Breeding for bio-fortification, GHG mitigation and carbon sequestration	2

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.

Advances in Biometrical Genetics **GPB-602**

Credit Hrs.: 3(2+1)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Continuous variation and evolutionary studies**	1
2.	**Genetic principles underlying continuous variation**	1
3.	**Qualitative vs quantitative traits – differences and significance**	1
4.	**Population types and approaches in biometrical studies**	1
5.	**Types of metrics – F_2, $F\infty$ and mixed**	1
6.	**Selection of parents in biometrical experiments**	1
7.	**Simultaneous selection models in breeding**	1
8.	**Application of multiple regression analysis in genotype selection**	1
9.	**Components of mean: Additive effect and breeding value**	1
10.	**Coefficient of gene dispersion and dominance**	1
11.	**Simple scaling test and expectations in different families**	1
12.	**Epistasis: specification and detection**	1
13.	**Weighted and unweighted joint scaling tests**	1
	Unit-II	
14.	**Effect of linkage on generation mean**	1
15.	**Specification of mean in G × E interaction**	1
16.	**Components of variance – concepts and advantages**	1
17.	**Variance in different generations; variance balance sheet**	1
18.	**Estimation of genetic parameters – weighted and unweighted**	1
19.	Least squares analysis in biometrical studies	1
20.	Random mating populations – concepts	1
21.	Experimental populations – BIPs, NCD-I, II, III	1
22.	Triple test cross – random mating populations and inbreds	1
23.	Estimation of linkage and non-allelic interactions	1
24.	Combining ability analysis – concepts and applications	1
25.	Hayman's approach to combining ability	1
	Unit-III	
26.	G × E interaction – concepts and significance	1
27.	Stability and adaptability of genotypes	1
28.	Advanced models of stability analysis – overview	1
29.	Pattern analysis and AMMI model	1
30.	Other multiplicative interaction models in stability analysis	1
31.	Merits and limitations of stability analysis methods	1
32.	Selection of best model – biplots and genotype mapping	1
33.	Construction of saturated linkage maps, concept of framework map development	1
34.	QTLs: markers, mapping populations, strategies, MAGIC population	1
35.	Marker Assisted Selection (MAS) – approaches and influencing factors	1
36.	Use of advanced software packages and interpretation of biometric data	1

Practical

S.No.	Topic
1.	Generation mean analysis – ABC scaling test (analysis & interpretation)
2.	Generation mean analysis – Joint scaling test
3.	Estimation of variance in different filial generations
4.	Interpretation of variance components
5.	Diallel analysis – numerical approaches
6.	Diallel analysis – graphical and combining ability
7.	Triallel analysis methods
8.	NC Designs – principles and applications
9.	Triple test cross analysis
10.	Stability analysis – Eberhart & Russell model
11.	AMMI model – Principal Component Analysis; AMMI and multiplicative models – interpretation; Genotype selection through AMMI, biplots, mapping
12.	Linkage map construction and QTL mapping – strategies; Phenotype-marker linkage studies
13.	Use of advanced software in biometrical data analysis

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.

Molecular Cytogenetics for Crop Improvement GPB-603

Credit Hrs.: 2(2+0)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Organization and structure of genomes in crop plants; Genome size and its variation in plants**	1
2.	**Organization of organellar genomes (chloroplast and mitochondrial**	2

	DNA); Nuclear DNA organization and chromatin structure	
3.	**Nuclear–cytoplasmic genome interactions and signal transduction**	1
4.	**Inheritance and expression of organellar DNA**	1
5.	**Variation in DNA content – the C-value paradox**	1
6.	**Sequence complexity: introns, exons, repetitive sequences and their roles**	1
7.	**Karyotyping techniques in crops; Chromosome banding methods; Chromosome painting approaches; Use of FISH and GISH in crop cytogenetics**	2
8.	**Tracking introgressions using molecular cytogenetics**	1
9.	**Localization and mapping of genes/genomic segments**	1
	Unit-II	
10.	**Pre-breeding applications of cytogenetical methods**	1
11.	**Gene location by deficiency method**	1
12.	**Interchanges – genetic consequences and identification of involved chromosomes**	1
13.	**Balanced lethal systems – maintenance and applications**	1
14.	**Use of multiple interchanges in producing inbreds**	1
15.	Transfer of genes using linked marker methods	1
16.	Duplications – production and applications	1
17.	Inversions – types and role in gene location	1
18.	B/A chromosome translocations in gene mapping	1
19.	Trisomics – types and production methods; Breeding behavior of trisomics and gene location; Use of balanced tertiary trisomics in hybrid seed production	2
20.	Monosomics – production methods and breeding behavior	1
21.	Gene mapping using monosomics	1
22.	Intervarietal substitutions – allelic and non-allelic interactions	1
23.	Telocentric chromosome method of mapping	1
	Unit-III	
24.	Cytogenomics – concept and applications; Tools and techniques of cytogenomics for crop improvement	2
25.	Chromosome sorting – methods and applications	1
26.	Isolation of specific chromosomes for molecular maps and gene localization	1
27.	Polyploidy in crop evolution and breeding	1
28.	Distant hybridization, barriers and chromosome behavior in interspecific and intergeneric crosses	1

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.-I 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

Plant Genetics Resources, Conservation and Utilization **GPB-604**
Credit Hrs.: 2(2+0)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Concept of natural reserves and natural gene banks**	1
2.	**In situ conservation of wild species in nature reserves; Components of in situ conservation**	2
3.	**Factors influencing conservation value**	1
4.	**National plan for in situ conservation; In situ conservation of agro-biodiversity on-farm**	1
5.	**Scientific basis of on-farm conservation; Building on-farm conservation initiatives; Implementation and management of on-farm conservation; Enhancing farmer benefits from local crop diversity**	2
6.	**Ex situ conservation – concept and components**	1
7.	**Plant genetic resources conservation in national gene banks**	1
8.	**Gene repositories and preservation under natural conditions**	1
9.	**Permafrost conservation and global examples**	1
	Unit-II	
10.	**Guidelines for seed multiplication and exchange**	1
11.	**Handling orthodox vs recalcitrant seeds**	1
12.	**Clonal repositories for vegetatively propagated crops**	1
13.	**Genetic stability under long-term storage**	1
14.	**In vitro storage: concepts and applications; Maintenance of in vitro cultures under different conditions; In vitro gene banks for fruit crops, spices, tubers, bulbous crops**	2
15.	Conservation of embryos, ovules, and cell cultures	1
16.	Protoplast, callus, pollen cultures and micropropagation	1
17.	Problems and prospects of in vitro conservation	1
	Unit-III	
18.	Cryopreservation – concepts and procedures	1
19.	Handling orthodox and recalcitrant seeds for cryopreservation	1
20.	Cryoprotectants, desiccation, rapid and slow freezing	1
21.	Vitrification and encapsulation/dehydration techniques	1
22.	National facilities for cryopreservation; Achievements, applications in agriculture and forestry	1

23.	Problems, prospects and challenges in cryopreservation	1
24.	Concept and procedure for PGR management	1
25.	Germplasm characterization – principles and methods	1
26.	Germplasm evaluation and utilization in breeding	1
27.	Concept and development of core and mini-core collections	2
28.	Registration of plant germplasm – guidelines and procedures	1

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.

Genomics in Plant Breeding GPB-605

Credit Hrs.: 3(3+0)

Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Introduction to plant genomes: nuclear, chloroplast and mitochondrial genomes**	1
2.	**Structure and organization of nuclear genomes**	1
3.	**Chloroplast and mitochondrial genomes – features and inheritance**	1
4.	**Genome size and complexity in plants: The C-value paradox and its implications**	1
5.	**Repetitive and unique DNA sequences in plant genomes**	1
6.	**Principles of genome sequencing – conventional approaches; Next-generation sequencing (NGS): general overview; Sequencing by synthesis (Illumina) – principle and applications; Sequencing by ligation methods**	2
7.	**Single-molecule real-time (SMRT) sequencing technologies**	1
8.	**Comparative analysis of sequencing platforms**	1
9.	**Applications of sequence information – structural genomics, functional genomics, comparative genomics**	2
10.	**Strategies for genome sequencing – shotgun sequencing**	1
11.	**Strategies for genome sequencing – clone-by-clone method**	1
12.	**Plant genome projects – progress and achievements**	1

	Unit-II	
13.	**Molecular maps – concepts and applications; Molecular markers and SNPs for map development; Genetic maps vs physical maps**	2
14.	**Linkage and LD-based gene mapping approaches, including gene/ QTL mapping**	1
15.	**Genome-wide association studies (GWAS) – concepts, examples and applications**	2
16.	**Integration of genetic and physical maps for map-based cloning of economically important genes**	1
17.	**Concept and importance of allele mining**	1
18.	**Diversity array technology (DArT) – concepts and applications**	1
19.	**Functional genomics – concepts and scope**	2
20.	**Forward and reverse genetics approaches**	1
21.	Activation tagging, Transposon tagging and insertional mutagenesis for functional analysis for crop improvement	2
22.	TILLING and ecoTILLING – concepts and applications	1
23.	Genome-wide and gene-specific transcriptomics approaches	2
24.	Serial analysis of gene expression (SAGE)	1
25.	Massively parallel signature sequencing (MPSS)	1
26.	Next-generation sequencing in transcriptomics	1
27.	Microarray technology for gene expression analysis	1
28.	Northern hybridization, RT-PCR, qRT-PCR methods	1
29.	Molecular beacon technology in gene expression studies	1
	Unit-III	
30.	Development and management of genomic databases	1
31.	Applications of bioinformatics tools/software in genomics	2
32.	Introduction to proteomics in plant breeding	1
33.	Introduction to metabolomics for crop improvement	1
34.	Phenomics – high-throughput tools and applications	2
35.	Genome editing tools – introduction	1
36.	CRISPR-Cas9 system – principle and applications	1
37.	TALENs and Zinc Finger Nucleases (ZFNs)	1
38.	Cisgenesis and intragenesis tools for crop improvement	1
39.	Genomics-based plant breeding: genome-wide diversity studies	1
40.	Marker-based and genomic selection strategies in plant breeding	2

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.

IPR and Regulatory Mechanism (e-course) **GPB-609**
Credit Hrs.: 1(1+0)
Theory

S.No.	Topic	No. of Lecture
	Unit-I	
1.	**Historical Perspectives, Introduction and meaning of Intellectual Property**	1
2.	**GATT, WTO, TRIPs, Provisions in TRIPS Agreement**	2
3.	**Berne Convention, Madrid Protocol, Budapest Treaty**	1
4.	**Indian Legislation for the protection of various types of Intellectual Properties**	1
5.	**Fundamentals of patents**	1
	Unit-II	
6.	**Copyrights; Geographical Indications**	1
7.	**Designs and layout, Trade secrets, Trademarks**	1
8.	**Traditional knowledge- meaning and rights of TK holders**	1
9.	Protectable subject matters, Integrated Circuits	1
10.	PPV & FR Act of India, Registration of Plant Varieties under PPV&FR Act 2001, Breeders, Researchers and Farmers Rights	2
	Unit-III	
11.	Indian Biological Diversity Act 2002 and its salient features, access and benefit sharing, Convention on Biological Diversity	1
12.	Protection in biotechnology, protection of other biological materials	1
13.	International Treaty on Plant Genetic Resources for Food and Agriculture	1
14.	Licensing of technologies	1
15.	Material transfer agreements	1
16.	Research collaboration Agreement; License Agreement	1

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.

Plant Pathology

Advances in Mycology **PL Path-601**
Credit Hrs.: 3(2+1)
Theory

S. No.	Theory	No. of Lecture
	UNIT – I	
10.	**General introduction**	1
11.	**Historical development and advances in mycology**	1
12.	**Recent taxonomic criteria, morphological criteria for classification**	1
13.	**Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy**	2
14.	**Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti**	1
15.	**Populationbiology pathogenic variability/vegetativecompatibility**	1
16.	**Heterokaryosis and parasexual cycle**	1
17.	**Sex hormones in fungi**	1
	UNIT – II	
9.	**Pleomorphism and speciation in fungi**	1
10.	**Mechanism of nuclear inheritance**	1
11.	**Mechanism of extra-nuclear inheritance**	1
12.	**Biodegradation**	1
13.	Ultra structures and chemical constituents of fungal cells	1
14.	functions of cell organelles	1
15.	Mitosis and meiosis	1
16.	gene action and regulation	2
	UNIT – III	
17.	Effects of fungal interaction with host plants and other microorganisms	2
18.	parasitism, symbiosis and commensalism	1
19.	Genetic Improvement of Fungal strains	1
20.	Fungal biotechnology	1
21.	Fungi mediated synthesis of nano particles – characterization process and application	1
22.	Mycotoxins problems and its management	1
	Total	**27**

Practical

S. No	Practical	No. of Lecture
1.	Isolation, purification and identification of cultures, spores and mating type determination	2
2.	Study of conidiogenesis -Phialides, poropores, arthospores	1
3.	Study of fruiting bodies in Ascomycotina	1
4.	Identification of fungi upto species level	1
5.	Study of hyphal anastomosis	1
6.	Morphology of representative plant pathogenic genera form different groups of	2

	fungi	
7.	Molecular characterization of fungi	2
Total		**10**

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.

Advances in Plant Virology — PL PATH-602

Credit Hrs.: 3(2+1)

Theory

S. No	Theory	No. of Lecture
	Unit I	
1.	**Origin, evolution and inter relationship with animal viruses**	1
2.	**Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus-specific cytological effects in infected plant cells**	2
3.	**Mechanisms leading to the evolution of new viruses/strains: mutation, recombination, pseudo-recombination, component re-assortment, etc.**	1
4.	**Major vector groups of plant viruses and their taxonomy**	1
5.	**Virus-vector relationship**	1
6.	**Molecular mechanism of virus transmission by vectors**	1
7.	**Terminologies used in immunology and serology**	1
8.	**Classification, structure and functions of various domains of Immunoglobulins**	1
	Unit II	
9.	**Production of Polyclonal and monoclonal antibodies for detection of viruses**	1
10.	**Immuno/serological assays: Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay**	2
11.	**Nucleic acid-based assays for detection of plant viruses**	1
12.	Polymerase Chain Reaction-based techniques: PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/q PCR	2
13.	Non-PCR based techniques: LAMP, Fluorescent in situ hybridization (FISH), dot blot hybridization	1
14.	Plant virus genome organization: general properties of plant viral genome – information content, coding and non-coding regions	1
15.	Replication, transcription and translational strategies of pararetroviruses, Gemini	1

	viruses, tobamo-, poty-, bromo-, cucumo-, ilar-, tospoviruses, satellite viruses and satellite RNA	
Unit III		
16.	Gene expression, regulation and viral promoters	1
17.	Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes	2
18.	Virus potential as vectors, genetically engineered resistance, transgenic plants	1
19.	Techniques and application of tissue culture for production of virus-free planting materials	1
20.	Phylogenetic grouping system based on partial/complete sequences of virus genomes	2
21.	Use of next-generation sequencing technology in plant virus discovery	2
Total		**27**

Practical

S. No	Practical	No. of Lecture
1.	Purification of viruses	2
2.	SDS-PAGE for molecular weight determination	2
3.	Production of polyclonal antiserum	2
4.	Purification of IgG and conjugate preparation	1
5.	Acquaintance with different serological techniques (i)DAC-ELISA (ii)DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA	2
6.	Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and autoradiography	2
7.	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)	2
8.	Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, ClustalX/W, Tm pred and Phylogeny programs)	2
Total		15

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.
- JM. 2006. Advances in Virus Research. Academic Press, New York.

Advances in Plant Pathogenic Prokaryotes PL PATH-603

Credit Hrs.: 3(2+1)

Theory

S. No.	Theory	No. of Lecture
	UNIT-I	
1.	**Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life**	1
2.	**RNA world**	1
3.	**Prokaryotic cytoskeletal proteins**	1
4.	**Flagella structure, assembly and regulation**	1
5.	**Structure and composition of (bacteria) cell wall/envelop**	1
6.	**Types of secretion systems (TI to TIV) and their molecular interaction**	1
7.	**Fimbriae and pili (Type IV pili)**	1
8.	**Bacterial chromosomes and plasmids, other cell organelles**	1
9.	**Growth, nutrition and metabolism in prokaryotes: Embden-Meyerhof-Parmas (EMP) pathway, Phosphoketolase pathway, and Entner-Doudoroff pathway**	1
10.	**Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life**	1
11.	**Current trends in taxonomy and identification of phytopathogenic prokarya**	1
12.	**International code of nomenclature**	1
13.	**Polyphasic approach**	1
	UNIT-II	
14.	**New/special detection methods for identification of bacterial plant pathogens**	1
15.	**Taxonomic ranks hierarchy, Identification techniques, Advances in classification and nomenclature**	1
16.	**Bacterial genetics: General mechanism of variability (mutation)**	1
17.	**Specialized mechanisms of variability**	1
18.	Transposable genetic elements in bacteria: integron and prophages	1
19.	Mechanism of gene transfer	1
20.	Pathogenicity islands	1
21.	Horizontal gene transfer	1
22.	Bacterial pan-genome	1
23.	Bacteriophages: Composition, structure and infection	1
24.	Classification and use of phages in plant pathology/bacteriology	1
	UNIT-III	

25.	Host-pathogen interactions: Molecular mechanism of pathogenesis	1
26.	Pathogenicity factors of soft rot, necrosis, wilt, canker, etc.	1
27.	Immunization, induced resistance/Systemic Acquired Resistance (SAR)	1
28.	Quorum sensing, Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis	1
29.	Bacterial secretion systems	1
30.	Pathogenicity of bacterial enzymes that degrade the cell walls	1
31.	Role of hrp/hrc genes and TALE effectors	1
32.	Synthesis and regulation of EPSs (exopolysaccharides)	1
33.	Beneficial prokaryotes: Endophytes, PGPR, phylloplane bacteria and their role in disease management	1
34.	Endosymbionts for host defence	1
35.	Advances in management of diseases caused by prokaryotes: Genetic engineering, RNA silencing, CRISPR-Cas9	1
Total		**35**

Practical

S. No	Practical	No. of Practical
1.	Pathogenic studies and race identification	1
2.	Plasmid profiling of bacteria	1
3.	Fatty acid profiling of bacteria	1
4.	RFLP profiling of bacteria and variability status	1
5.	Endospore	1
6.	Flagella staining	1
7.	Test for secondary metabolite production, cyanides	1
8.	Eps	1
9.	Siderophore	1
10.	Specific detection of phytopathogenic bacteria using species/ pathovar specific primers	1
11.	Basic techniques in diagnostic kit development	1
12.	Molecular tools to identify phytoendosymbionts	1
13.	Important and emerging diseases and their management strategies.	1
Total		**13**

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.

Molecular Basis of Host-Pathogen Interaction **PL PATH-604**

Credit Hrs.: 3(2+1)

Theory

S. No	Theory	No. of Lecture
	Unit- I	
1.	**History of host plant resistance and importance to agriculture**	1
2.	**Importance and role of biotechnological tools in plant pathology**	1
3.	**Basic concepts and principles to study host-pathogen relationship**	1
4.	**Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions**	2
5.	**Different forms of plant-microbe interactions and nature of signals/effectors underpinning these interactions**	1
6.	**Plant innate immunity: PAMP/DAMP**	1
7.	**Molecular basis of host-pathogen interaction – fungi, bacteria, viruses and nematodes**	1
8.	**Recognition systems**	1
9.	**signal transduction pathways**	1
10.	**Induction of defence responses – Hypersensitive Response (HR), Programmed Cell Death (PCD), reactive oxygen species**	1
	Unit-II	
11.	**Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR)**	1
12.	**Pathogenesis-related proteins and phytoalexins**	1
13.	**virus-induced gene silencing**	1
14.	**Molecular basis of gene-for-gene hypothesis**	1
15.	**R-gene expression and transcription profiling**	1
16.	Mapping and cloning of resistance genes, marker-aided selection, and pyramiding of R-genes	2
17.	Gene-for-gene systems: background, genetics, phenotypes, molecular mechanisms	1
18.	Races and breakdown of resistance (boom-and-bust cycles)	1
19.	Coevolution – arms race and trench warfare models	1
20.	Metapopulations, cost of resistance, cost of unnecessary virulence	1
	Unit- III	
21.	GFG in agricultural crops vs. natural populations	1
22.	Durability of resistance, erosion of quantitative resistance	1
23.	Pathogen population genetics and durability	1
24.	Viruses vs. cellular pathogens	1
25.	Gene deployment and cultivar mixtures	1
26.	Disease emergence and host specialization	1
27.	Circadian clock genes in relation to innate immunity	1
28.	Biotechnology and disease management: development of disease-resistant plants using genetic engineering approaches	2
29.	Different methods of gene transfer	1
30.	Biosafety issues related to GM crops	1

Total	33

Practical

S. No	Practical	No. of Practical
1.	Protein, DNA isolation, plasmid extraction	1
2.	DNA isolation	1
3.	RNA isolation	1
4.	PCR analysis, DNA and Protein electrophoresis	2
5.	bacterial transformation	2
6.	Gene mapping and marker assisted selection	2
7.	Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management	2
Total		11

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.

Principles and Procedures of Certification — PL PATH-605

Credit Hrs.: 1(1+0)

Theory

S. No	Theory	No. of Lecture
	Unit I	
1.	**Introduction to certification**	**1**
2.	**International scenario of certification and role of ISTA, EPPO, OECD, etc. in certification and quality control**	**1**
3.	**Case studies of certification systems of USA and Europe**	**1**
4.	**National Regulatory mechanism and**	**1**
5.	**Certification system including seed certification**	**1**
	Unit II	
6.	**Minimum seed certification standards**	**1**
7.	National status of seed health in seed certification	1
8.	Methods for testing genetic identity, physical purity, germination percentage, seed health, etc.	1
9.	Fixing tolerance limits for diseases and insect pests in certification and quality control programmes	1
	Unit III	

10.	Methods used in certification of seeds, vegetative propagules and in-vitro cultures	1
11.	Accreditation of seed testing laboratories	1
12.	Role of seed/planting material health certification in national and international trade	1
Total		**12**

Suggested Reading

- 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.

Plant Biosecurity and Biosafety — PL PATH-606

Credit Hrs.: 2(2+0)

Theory

S. No	Theory	No. of Lecture
	Unit I	
1.	**History and Concept of biosecurity**	**1**
2.	**Components of biosecurity. Quarantine. Invasive Alien Species. Biowarfare. Emerging/resurgence of pests and diseases**	**1**
3.	**Introduction and history of biosecurity and its importance. Introduction and history of biosecurity and its importance**	**1**
4.	**National Regulatory Mechanism and International Agreements/Conventions, Agreement on Application of Sanitary and Phytosanitary (SPS) Measures**	**1**
5.	**World Trade Organization (WTO), Convention on Biological Diversity (CBD)**	**1**
	Unit II	
6.	**Interanational standards for phytosanitary measures**	**1**
7.	**Pest risk analysis and risk assessment models**	**1**
8.	Pest information system, early warning and forecasting system	**1**
9.	Use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity	1
10.	Pest/disease and epidemic management	1
	Unit III	
11.	Strategies for combating risks and costs associated with agroterrorism events, mitigation planning	1
12.	Integrated approach for biosecurity	1
13.	Biosafety policies and regulatory mechanism	1
14.	Cartagena Protocol on Biosafety and its implications. Issues related to release of genetically modified crops. Emerging/resurgence of pests and diseases in the	1

	changing scenario of climatic conditions	
	Total	**14**

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 and Kavita Gupta 2006. Plant Biosecurity in India – Status and Strategy. Asian Biotechnology and Development Review 9(2): 3963.
- Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon BS (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

Soil Science

Recent trends in soil physics **Soils-601**
Credit Hrs.: 2(2+0)
Theory:

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept**	2
2.	**Chemical potential of soil water and entropy of the system, soil-plant atmospheric continuum (SPAC)**	2
3.	**Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows**	2
4.	**Development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity;**	2
5.	**limitations of Darcy's law; numerical solution for one dimensional water flow. Theories of horizontal and vertical infiltration under different boundary conditions**	3
	UNIT-II	
6.	**Movement of salts in soils, models for miscible-immiscible displacement**	2
7.	Diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.	2
8.	Soil air and aeration, mass flow and diffusion processes;	2
9.	Thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil;	3
10.	Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.	3
	UNIT-III	
11.	Soil crust and clod formation; structural management of puddled rice soils, Soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture	2
12.	Solar and terrestrial radiation measurement, dissipation and distribution in soil- crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models	2
13.	Canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra- red thermometer.	2
	Total-	28

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.

Modern Concept in Soil Fertility **Soil-602**

Credit Hrs.: 2(2+0)

Theory

S.No.	Theory Topics	Classes
	Unit I	
1	**Nutrient availability-concept and relationships, modern concepts of nutrient s availability; soil colloids and nutrient availability**	**3**
2	**Soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices**	**3**
3	**Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants**	**3**
4	**models for transformation and movement of major micro nutrients in soils**	**2**
5	**Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils**	**2**
	Unit II	
6	Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting	2
7	Role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture	2
8	Monitoring physical, chemical and biological changes in soils; permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping	2
9	Direct, residual and cumulative effect of fertilizer use	2
	Unit III	
10	Carbon– a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes	2
11	Greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity	2
	Total	**27**

References:

- 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.
- 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.

Physical Chemistry **Soil-603**

Credit Hrs.: 2(2+0)

Theory

S.No.	Theory Topics	Classes
	Unit I	
1.	**Colloidal chemistry of in organic and organic components of soils– their formation, clay organic interaction**	**4**
2.	**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**	**3**
3.	**Thermodynamics of nutrient transformations in soils**	**4**
4.	**Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular inter action**	**2**
5.	Adsorption/desorption isotherms-Langmuir adsorption isotherm	2
	Unit II	
6.	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)	4
7.	Common solubility equilibria-carbonates, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use)	2
	Total	**21**

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.
- van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

Soil Genesis and Micromorphology — Soil 604

Credit Hrs.: 2(2+0)

Theory

S. No.	Topics	Lectures
	Unit I	
1	**Pedogenic evolution of soils**	1
2	**soil composition**	1
	Soil characterization	1
3	**Weathering and soil formation**	1
4	**Factors and paedogenic processes**	2
	Unit II	
5	**Rocks and minerals and their classification**	2
6	**Stability and weathering sequences of minerals**	1
7	**Assessment of soil profile development by chemical analysis**	2
9	**Laboratory Analysis for Soil Classification**	2
	Unit III	
10	Micro-pedological features of soils–their structure, fabric analysis,	2
11	Role of Soil genesis	1
12	Introduction to Soil Classification	1
13	Concept and Importance of Soil Classification	2
14	Historical Evolution of Soil Classification Systems	1
15	Principles and Objectives of Soil Classification	1
16	Soil Taxonomy (USDA Sys Soil classification	2
17	Soil Classification Based on Agro-Ecological Zones	2
	Total	26

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. 4thEd. Panima Publ.
- Dixon JB and Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Societyof 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.

Biochemistry of Soil Organic Matter — Soils- 605

Credit Hrs.: 2(2+0)

Theory:

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Organic matter in soils and its maintenance**	**2**
2.	**Role of organic matter in soil productivity**	**2**
3.	**Humus levels in soils**	**2**
4.	**Current thinking on the maintenance of organic matter in the soils.**	**2**
5.	**Carbon retention and sequestration**	**3**
	UNIT-II	
6.	**Biochemistry of the humus formation**	2
7.	Different pathways for humus synthesis in soil	2
8.	Soil carbohydrates and lipids.	2
9.	Nutrient transformation–N, P,S; trace metal interaction with humicsubstances	3
10.	Significance of chelation reactions in soils	2
	UNIT-III	
11.	Reactive functional groups of humic substances	2
12.	Adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes	2
13.	Clay- organic matter complexes. Humus-pesticide interactions in soil, mechanisms	2
	Total-	28

Suggested Reading

- 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

Soil Resource Management — Soil-606

Credit Hrs.: 3(3+0)

Theory

S.No.	Topics	Lectures
	UNIT-I	
1.	**Relevance of soil management to sustainable agriculture;**	3
2.	**Soil as a source and sink of greenhouse gases**	2
3.	**Soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves geogenic source of raw materials**	2
4.	**Concept of sustainable land management (SLM), spatial variability of soils**	2
5.	**Soil quality and food security**	1
6.	**Soil quality indices, conservation agriculture in relation to soil**	2

	quality	
7.	**soil resilience and resistance.**	2
	UNIT-II	
8.	**Dry land management**	2
9.	**Management of forest, peat and muck soils.**	2
10.	Soil conservation planning; land capability classification; waterlogged and wetlands; land restoration	3
11.	Soil conservation in special problem areas such as hilly, arid and semi-arid regions,	2
12.	Conservation techniques–erosion control,	1
13.	Reclamation of saltaffected soils;	2
	UNIT-III	
14.	Mine land reclamation, afforestation	1
15.	Organic products, soil fauna and biodegradation.	1
16.	Watershed management-concept, objectives and approach;	3
17.	Water harvesting and recycling;	2
18.	Case studies in respect to monitoring and evaluation of watersheds	2
	Total	**35**

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.

Fruit Science

Innovative Approaches in Fruit Breeding **FSC-601**
Credit Hours: 3(3+0)
Theory:

S. No.	Topics	Number of Lectures
	UNIT-I	
1.	**Modern trends in fruit breeding with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc.**	**03**
2.	**Scope and importance of fruit breeding**	**01**
3.	**Major problems in fruit breeding**	**01**
4.	**Inheritance Patterns in fruit crops**	**01**
5.	**Breeding Systems in different fruit crops**	**01**
6.	**Genetics of important traits and their inheritance pattern, variations and natural selection,**	**01**
7.	**Spontaneous mutations, incompatibility systems in fruits**	**02**
8.	**Breeding for Specific Traits Plant Architecture,**	**01**
9.	**Stress Tolerance and Fruit Quality**	**01**
10.	**Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes**	**03**
11.	**Stress tolerance in fruit crops**	**01**
12.	**Crop specific quality traits in fruit crops**	**01**
13.	**Use of apomixes in fruit crops and write their types**	**01**
	UNIT-II	
14.	**Gene introgression and wide hybridization (alien genes).**	**01**
15.	**Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops**	**02**
16.	Fast track breeding	01
17.	Marker assisted selection and breeding (MAS and MAB)	01
18.	Use of genomics and gene editing technologies	01
19.	Mango: Breeding objectives, Problems and achievement in mango	01
20.	Banana: Breeding objectives, Problems and achievement in banana	01
21.	Guava: Breeding objectives, Problems and achievement in guava	01
22.	Papaya: Breeding objectives, Problems and achievement in papaya	01
23.	Citrus: Breeding objectives, Problems and achievement in citrus	01
24.	Grapes: Breeding objectives, Problems and achievement in mango	01
25.	Pomegranate: Breeding objectives, Problems and achievement in pomegranate	01
26.	Litchi: Breeding objectives, Problems and achievement in litchi	01
	UNIT-III	
27.	Apple: Breeding objectives, Problems and achievement in apple	01
28.	Pear: Breeding objectives, Problems and achievement in pear	01

29.	Strawberry: Breeding objectives, Problems and achievement in strawberry	01
30.	Kiwifruit: Breeding objectives, Problems and achievement in kiwifruit	01
31.	Plums: Breeding objectives, Problems and achievement in plums	01
32.	Peaches: Breeding objectives, Problems and achievement in peaches	01
33.	Apricot: Breeding objectives, Problems and achievement in apricot	01
34.	Cherries: Breeding objectives, Problems and achievement in cherries	01
35.	Nectarines: Breeding objectives, Problems and achievement in nectarines	01
36.	Nut crops: Breeding objectives, Problems and achievement in nut crops	01

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.

Modern Trends in Fruit Production — FSC-602

Credit Hours: 3 (3+0)

Theory:

S. No.	Topic	Number of Lectures
	UNIT-I	
1.	**Modern Trends in Fruit Production (General Concepts and Current Scenario; National and International scenario; national problems; 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; 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) of Mango**	**03**

2.	**Modern Trends in Fruit Production of Banana**	**02**
3.	**Modern Trends in Fruit Production of Citrus**	**03**
4.	**Modern Trends in Fruit Production of Papaya**	**02**
5.	**Modern Trends in Fruit Production of Litchi**	**02**
6.	**Modern Trends in Fruit Production of Guava**	**02**
	UNIT-II	
7.	**Modern Trends in Fruit Production of Pomegranate**	**03**
8.	**Modern Trends in Fruit Production of Apple**	**03**
9.	Modern Trends in Fruit Production of Pear	03
10.	Modern Trends in Fruit Production of Peach	03
11.	Modern Trends in Fruit Production of Plum	02
	UNIT-III	
12.	Modern Trends in Fruit Production of Apricot	02
13.	Modern Trends in Fruit Production of Cherry	02
14.	Modern Trends in Fruit Production of Walnut	02
15.	Modern Trends in Fruit Production of Pecan	02
16.	Modern Trends in Fruit Production of Strawberry	02
17.	Modern Trends in Fruit Production of Kiwifruit	02

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. Naya Udyog, 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.

Recent Developments in Growth Regulation **FSC-603**
Credit Hours: 3(3+0)
Theory:

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Eco-physiological influences on growth and development of fruit crops * Light, temperature, water, nutrients and CO_2 effects**	**02**
2.	**Physiology of flowering in fruit crop * Induction, differentiation and regulation**	**02**
3.	**Physiology of fruit set * Pollination, fertilization and role of hormones**	**02**
4.	**Crop load management * Thinning, pruning, chemical and mechanical regulation**	**02**
5.	**Assimilate partitioning and distribution * Source–sink relationships and carbohydrate metabolism**	**02**
6.	**Concepts of phytohormones and growth regulators in fruit culture**	**01**
7.	**Structure, biosynthesis, and metabolic role of major phytohormones * Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene and Brassinosteroids**	**02**
8.	**Morphogenetic effects of growth promoters and growth retardants**	**01**
9.	**Absorption, translocation and degradation of phytohormones**	**01**
	UNIT-II	
10.	**Internal and external factors influencing hormone synthesis and activity**	**02**
11.	**Biochemical action of growth substances – growth promotion and inhibition**	**02**
12.	**Root and canopy regulation through growth substances**	**02**
13.	Canopy management strategies for fertigated orchards	02
14.	Growth regulation in propagation* Seed germination, vegetative propagation, rooting and graft union formation	01
15.	Embryogenesis and seed dormancy regulation	01
16.	Bud dormancy – induction, maintenance and release	01
17.	Fruit bud initiation and differentiation	01
18.	Regulation of flowering and off-season production	01
19.	Flower drop and thinning – physiological and chemical control	01
	UNIT-III	
20.	Fruit set and development physiology	02
21.	Fruit drop – causes and management	02
22.	Parthenocarpy – natural and induced	01
23.	Fruit maturity and ripening physiology	02
24.	Postharvest physiology and storage regulation	01
25.	Molecular approaches in crop growth regulation * Gene expression, molecular markers and biotechnology applications	02
26.	Current research trends in fruit crop growth and developmental regulation	02

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.

Abiotic Stress Management in Fruit Crops FSC-606

Credit Hours: 3(2+1)

Theory

S.No.	Topics	Number of Lectures
	UNIT-I	
1.	**Basic Aspects and Principles of abiotic stress in different fruit crops**	**02**
2.	**Major challenges for fruit production in stress areas**	**01**
3.	**Impact and mechanism of abiotic stresses in fruit crops**	**01**
4.	**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.).**	**02**
5.	**Pollution – increased level of CO2, industrial wastes, Impact of stress in different areas of fruit crop production**	**01**
6.	**Stress indices: Definition and types**	**01**
7.	**Physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.**	**02**
8.	**Assessment, Physiology and Performance: Crop modelling for stress situations in different fruit crops**	**01**
	UNIT-II	
9.	**Cropping systems in different fruit crops, 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.**	**04**
10.	Stress Management: Mitigation Measures and Conservation Practices: Greenhouse effect and Methane emission its relevance to abiotic stresses.	02
11.	Use of anti transpirants in stress management, mode of action and practical use.	01
12.	Use of PGRs in stress management, mode of action and practical use.	01

13.	Mulching: Definition of Mulching, Types and merit and demerit of mulching, use of mulching under stress condition	02
14.	Hydrophilic polymers: Definition, applications of Hydrophilic polymers, current trends and vision for the future	02
	UNIT-III	
15.	Rain water harvesting: Key components of a rainwater harvesting system, methods of RW, Benefits of RW, increasing water use efficiency.	02
16.	Skimming technology.	01
17.	Contingency planning to mitigate different stress situations, stability and sustainability indices.	02
18.	Understanding various stresses (drought, heat, salinity, cold, UV radiation)	01
19.	HSP inducers in stress management techniques of soil moisture conservation,	01
20.	Physiological parameters such as relative water content (RWC)	01
21.	Biotechnological strategies for amelioration of abiotic stress	01

Practical

S. No.	Topics	Number of Lectures
1.	To study about seed treatment/ hardening practices	01
2.	To study about container seedling production.	01
3.	To study about analysis of soil moisture estimates (FC, ASM and PWP)	02
4.	To study about 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	02
5.	To study about biological efficiencies, WUE, solar energy conversion and efficiency	01
6.	To study about crop growth sustainability indices and economics of stress management	02
7.	Visit to orchards and watershed locations	01

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.

Maloo SR. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy, India.

Nickell LG. 1983. *Plant Growth Regulating Chemicals*. CRC Publication, USA.

Rao NKS, Shivashankar KS and Laxman RH. 2016. *Abiotic Stress Physiology of Horticultural Crops.* Springer.

Turner NC and Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*.John Wiley & Sons, USA.

Vegetable Science

Recent trends in Vegetable Production **VSC-601**
Credit Hours: 3(3+0)
Theory:

S. No.	Topic	Number of Lectures
	UNIT-I	
1.	**Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties.**	**01**
2.	**Hi-tech nursery management in Vegetables**	**01**
3.	**Modern concepts in water and weed management in Vegetables**	**01**
4.	**Physiological basis of growth, yield and quality as influenced by chemicals and growth regulators in Vegetables**	**02**
5.	**Role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management; nutritional deficiencies/ disorders and correction methods**	**02**
6.	**Different cropping systems and mulching in Vegetables**	**01**
7.	**Protected cultivation of vegetables – Tomato, Sweet Pepper, Cucumber and Sprouting Broccoli**	**02**
8.	**Containerized culture for year-round Vegetable Production**	**01**
9.	**Low cost polyhouse; net house production; crop modelling, organic gardening; vegetable production for pigments, export and processing of Vegetables**	**02**
10.	**Recent trends in production technology of Tomato**	**01**
11.	**Recent trends in production technology of Brinjal**	**01**
12.	**Recent trends in production technology of Chilli and Sweet Pepper**	**01**
	UNIT-II	
13.	**Recent trends in production technology of Potato**	**02**
14.	**Recent trends in production technology of Cole crops: Cabbage, Cauliflower, Knol-Khol and Sprouting Broccoli**	**02**
15.	**Recent trends in production technology of Okra**	**01**
16.	**Recent trends in production technology of Onion**	**01**
17.	Recent trends in production technology of Peas and Beans	02
18.	Recent trends in production technology of Amaranth and Drumstick	02
19.	Recent trends in production technology of Root crops: Carrot, Beet Root, Turnip and Radish	03
	UNIT-III	
20.	Recent trends in production technology of Cucurbits: Water Melon, Musk Melon, Bottle Gourd, Bitter Gourd, Pointed Gourd and Pumpkin	04

21.	Recent trends in production technology of Tuber crops: Sweet Potato, Cassava, Elephant Foot Yam, Dioscorea and Taro	03
22.	Role of Remote sensing and GIS technology in Vegetable Production	02

Suggested Reading

Bose TK and Som NG. 1986. *Vegetable crops of India*. Naya prokash.

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.

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*. 2nd edn, 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.

Advances in Breeding of Vegetable Crops **VSC-602**
Credit Hours: 3(3+0)
Theory:

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**General principles of vegetable breeding: Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, gene banks, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant ideotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, speed breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio- fortification, *in-vitro* breeding, marker assisted breeding, haploidy, development of transgenic, recent breeding achievement in vegetable crops.**	**04**
2.	**Breeding of solanaceous crops- Tomato, Brinjal, Chilli and Potato**	**07**
3.	**Breeding of okra**	**02**
	UNIT-II	
4.	**Breeding of cucurbits**	**04**
5.	**Breeding of cole crops**	**04**
6.	Breeding of legumes- Pea and Beans	02
7.	Breeding of leafy vegetables- Amaranthus, Palak, Chenopods and Lettuce	03
	UNIT-III	
8.	Breeding of root crops- Carrot, Beetroot, Radish and Turnip	04
9.	Breeding of bulb crops- Onion and Garlic.	02
10.	Breeding of tuber crops – Sweet potato, Tapioca, Elephant foot yam, Colocasia and Dioscorea.	05

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.

Abiotic Stress Management in Vegetable Crops VSC-603

Credit Hours: 3(2+1)

Theory:

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Environmental stress— definitions, scope, importance and its types**	2
2.	**Soil parameters and stress – role of soil pH, EC, organic matter, texture and structure**	1
3.	**Classification of vegetable crops based on susceptibility and tolerance to various types of stress – drought, salinity, heat, cold and water logging**	4
4.	***Mechanism and measurements*—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops**	3
	UNIT-II	
5.	***Soil-plant-water relations*—under different stress conditions drought, water logging, soil salinity, frost and heat stress) in vegetable crops production and their management practices**	5
6.	Techniques of vegetable growing under water deficit, water logging, salinity and sodicity	4
	UNIT-III	
7.	Use of chemicals in stress alleviation – antitranspirants, Osmo protectants, PGRs (CCC, ABA, kaolin and glycine betaine)	4
8.	Techniques of vegetable cultivation under high and low temperatures, future strategies (protected cultivation, genetic improvement and climate-smart technologies)	4

Practical

S. No.	Topic	Number of Lectures
1.	Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops – drought, salinity, heat, cold and water logging.	**03**

2.	Classification of vegetable crops based on susceptibility and tolerance to various types of stress	**02**
3.	Measurement of tolerance to various stresses in vegetable crops	**02**
4.	Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions	**03**
5.	Use of chemicals for alleviation of different stresses	**02**

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.

Seed Certification, Processing and Storage of Vegetable Seeds VSC-604

Credit Hours: 3(2+1)

Theory:

Total Lectures: 28

S. No.	Topic	No. of Lectures
	UNIT-I	
1.	**Seed certification, history, concepts Principles and objectives**	**1**
2.	**Seed certification agency, phases of seed certification**	**2**
3.	**Indian Minimum seed Certification standards, Seed standards(genetic purity, physical purity, Germination, Seed health and Moisture)**	**2**
4.	**Planning and management of seed certification programme**	**1**
5.	**Principles and procedures of field inspection, seed sampling, testing and granting certification and OECD certification Schemes**	**2**
6.	**Principles of seed processing, Methods of seed drying and cleaning**	**1**
7.	**Seed processing plant- Layout and design**	**1**
	UNIT-II	
8.	**Seed processing equipments**	**2**

9.	**Seed treatment, seed quality enhancement, packaging and marketing**	**2**
10.	Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm and cryopreservation)	**3**
11.	Factors affecting seed longevity in storage (Pre and post harvest factors)	**3**
	UNIT-III	
12.	Seed aging and deterioration, maintenance of seed viability and Seed vigor during storage	**3**
13.	Seed storage methods and storage structures	**3**
14.	Transportation and marketing of seeds	**2**

Practical

S. No.	Topic	No. of Lectures
1.	General procedures of seed certification	01
2.	Field inspection and standards	01
3.	Isolation and rouging	01
4.	Inspection and sampling at harvesting, threshing and processing	02
5.	Testing physical purity, germination and moisture	02
6.	Grow-out test	01
7.	Visit to regulatory seed testing and plant quarantine laboratories	01
8.	Seed processing plants and commercial seed stores	01

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

Supporting Course

Statistical Methods for Applied Sciences **STAT-502**
Credit Hours: 4(3+1)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1	**Box-plot, Descriptive statistics**	05
2	**Exploratory data analysis**	02
3	**Theory of probability**	03
4	**Random variable and mathematical expectation.**	02
5	**Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications.**	06
	Unit II	
6	**Concept of sampling distribution: chi-square, *t* and *F* distributions**	04
7	**Tests of significance based on Normal, chi-square, *t* and *F* distributions.**	04
8	Introduction to theory of estimation and confidence-intervals	02
9	Simple and multiple correlation coefficient, partial correlation, rank correlation	02
10	Simple and multiple linear regression model	02
	Unit III	
11	test of significance of correlation coefficient and regression coefficients, Coefficient of determination	02
12	Fitting of quadratic models	01
13	Introduction to ANOVA: One way and Two Way	02
14	Introduction to Sampling Techniques	02
15	Introduction to Multivariate Analysis	01
16	Transformation of Data.	02

Practicals:

S. No.	Topics	No. of practical
1	Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal	03
2	Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F	03
3	Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model	03
4	Non-parametric tests. ANOVA: One way, Two Way, SRS	03

Suggested Reading

- 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

Experimental Designs **STAT-511**
Credit Hours: 3(2+1)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1	**Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control**	03
2	**Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design**	04
3	**Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding**	04
	Unit II	
4	**Split plot and strip plot designs**	04
5	Analysis of covariance	02
6	Missing plot techniques in randomized block and Latin square designs	04
	Unit III	
7	Transformations	02
8	Balanced Incomplete Block Design, resolvable designs and their applications.	03
9	Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis	03

Practicals:

S. No.	Topics	No. of Practical
1	Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD	03
2	Analysis of factorial experiments.	02
3	Analysis with missing data.	03
4	Split plot design	02
5	Strip plot design	02

Suggested Reading

- 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.

Basic Sampling Techniques **STAT-512**
Credit Hours: 3(2+1)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1	**Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population**	04
2	**Sampling and non-sampling errors**	01
3	**Simple random sampling with and without replacement**	03
4	**Sampling for proportion**	02
	Unit II	
5	**Determination sample size**	02
6	**Inverse sampling**	02
7	Stratified sampling	04
8	Cluster sampling	02
	Unit III	
9	Multi-stage sampling	02
10	Systematic sampling	01
11	Introduction to PPS sampling	01
12	Use of auxiliary information at estimation, Ratio product and regression estimators	03
13	Double Sampling	01

Practicals:

S. No.	Topics	No. of practical
1	Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.	03
2	Simple random sampling, determination of sample size, inverse sampling	03
	Stratified sampling, cluster sampling and systematic sampling	02
3	Estimation using ratio and regression estimators	03
4	Estimation using multistage design, double sampling	03

Suggested Reading

- 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

Applied Regression Analysis **STAT 521**
Credit Hours: 3(2+1)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1	**Introduction to correlation analysis and its measures**	02
2	**Correlation from grouped data**	02
3	**Rank correlation and Testing of population correlation coefficients**	02
4	**Multiple and partial correlation coefficients and their testing**	02
	Problem of correlated errors and Auto correlation,	02
5	**Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation**	02
	UNIT-II	
6	**Analysis of collinear data; Detection and correction of multi collinearity**	02
7	Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients	02
8	Multiple and partial regressions	02
	Diagnostic of multiple regression equation, Concept of weighted least squares	02
	UNIT-III	
9	Regression equation on grouped data; Various methods of selecting the best regression equation	02
10	Concept of nonlinear regression and fitting of quadratic, exponential and power curves	02
11	Economic and optimal dose, Orthogonal polynomial	02

Practicals:

S. No.	Topics	No. of practical classes
1	Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses	04
2	Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection	04

3	Handling of correlated errors, multicollinearity	03
4	Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials	03

Suggested Reading

- *Kleinbaum DG, Kupper LL, Nizam A. 2007. Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.*
- *Draper NR and Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.*
- *Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.*
- *Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.*
- *Kutner MH, Nachtsheim CJ and Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student CD. McGraw Hill.*

Data Analysis Using Statistical Packages **STAT 522**
Credit Hours: 3(2+1)
Theory

S. No.	Topics	No. of lectures
	Unit I	
1	**Introduction to various statistical packages: Excel, R, SAS, SPSS**	03
2	**Data Preparation**	01
3	**Descriptive statistics**	02
4	**Exploratory data analysis**	01
5	**Test for normality**	01
6	**Testing of hypothesis using chi-square, *t* and *F* statistics and Z-test**	02
	Unit II	
7	**Data preparation for ANOVA and ANCOVA**	02
8	**Factorial Experiments, contrast analysis**	02
9	Multiple comparisons, Analyzing crossed and nested classified designs	02
10	Analysis of mixed models	01
11	Estimation of variance components	01
12	Correlation and regression analysis,	02
	Unit III	
13	Probit, Logit and Tobit Models	02
14	Discriminant function	01
15	Factor analysis	01
16	Principal component analysis	01
17	Analysis of time series data	01
1	Fitting of non-linear models; Neural networks	01

Practicals:

S. No.	Topics	No. of practical classes
1	Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data	03
2	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	03
3	Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components	02
4	Linear regression, Multiple regression, Regression plots	02
5	Discriminant analysis - fitting of discriminant functions, identification of important variables	02
6	Factor analysis. Principal component analysis - obtaining principal component	02

Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
- Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall

Common Course

Library and Information Services **PGS-501**
Credit Hrs.: 1 (0+1)
Practical

S. No.	Description
1.	Introduction to library and its services
2.	Role of libraries in education, research and technology transfer
3.	Classification systems and organization of library
4.	Sources of information- Primary Sources, Secondary Sources and Tertiary Sources
5.	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.)
6.	Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography
7.	Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services
8.	Use of Internet including search engines and its resources; e- resources access methods.
9.	What is Plagiarism? in Research, Definition Type and How to Avoid, and Laws
10.	AI Tools in Research

Technical Writing and Communication Skills **PGS-502**
Credit Hrs.: 1(0+1)
Practical

S.No.	Topic
	Technical Writing
1.	**Introduction to Scientific & Technical Writing** • Content: Various forms of scientific writings – theses, technical papers, reviews, manuals, research notes, popular articles. • **Activity**: Students are given 4 short text samples (e.g., abstract, review, manual, article) They identify the form and purpose.
2.	**Thesis Structure (Part I)** • Content: Parts of thesis/research communication – title page, authorship, contents, preface, introduction, review of literature, material & methods. • **Activity**: Students prepare a sample *title page* and *contents page* for a hypothetical thesis.
3.	**Thesis Structure (Part II) + RVSKVV Thesis Manual Overview** • Content: Results, discussion, summary; overview of RVSKVV Gwalior Thesis Manual (formatting, style, submission rules). • **Activity**: Students analyze a sample RVSKVV thesis (provided by teacher) and highlight 5 formatting rules they must follow.
4.	**Writing Abstracts, Summaries & Précis, Citations** • Content: Structure of abstract, how to write a précis, difference between summary & abstract, rules of citation. • **Activity**: Students write a *150-word abstract* of a given passage and also compress the same into a *précis (1/3rd length)*.
5.	**Abbreviations, Illustrations, Captions, Editing, Proofreading & Review Articles**

	• Content: Common abbreviations, rules for figures/tables, pagination, numberingediting/proofreading, basics of review article writing. • **Activity**: Students are given a short passage full of errors + 1 table without caption → They edit, proofread, and write the correct table caption.
	Communication Skills
6.	**Grammar Essentials (Parts of Speech & Tenses)** • Content: Overview of nouns, pronouns, verbs, adjectives, adverbs, prepositions, conjunctions, interjections; tense forms. • **Activity**: Students construct 10 sentences using different tenses and label each word with its part of speech.
7.	**Clauses & Sentence Structure** • Content: Main clause, subordinate clause (noun, adjective, adverb), compound vs. complex sentences. • **Activity**: Students transform simple sentences into complex sentences using different clauses and learn transformation of sentences.
8.	**Clause Continue and Punctuation Marks** • Content: Uses of full stop, comma, semicolon, colon, quotation marks, apostrophe, dash, brackets. • **Activity**: Students are given an unpunctuated paragraph and must rewrite it with correct punctuation.
9.	**Error Analysis (Common Errors)** • Content: Subject-verb disagreement, preposition misuse, redundancy, wrong tense usage. • **Activity**: Peer activity – each group is given some sentences with errors to correct and explain.
10.	**Concord (Subject–Verb Agreement) & Collocations** • Content: Rules of concord, common collocations in academic English. • **Activity**: Fill-in-the-blanks quiz: choose the correct verb and collocations (make/do decision, strong/powerful tea etc.).
	Communication Skills
11.	**Phonetics (Symbols & Transcription – I)** • Content: Introduction to IPA (International Phonetic Alphabet), vowels, consonants. • **Activity**: Students transcribe simple words into phonetic symbols.
12.	**Phonetics (Symbols & Transcription – II)** • Content: Practice with advanced phonetic transcription, scientific terms. • **Activity**: Students transcribe technical/scientific words.
13.	**Accentual Patterns & Weak Forms** • Content: Stress in words, weak forms in connected speech. • **Activity**: Students practice reading sentences aloud, marking stress and weak forms.
14.	**Group Discussions** • Content: Structure of GD, skills: turn-taking, argument, evidence, politeness. • **Activity**: Mock GD on a topic (e.g., "Organic vs. Chemical Farming"). Teacher observes and gives feedback.
15.	**Interviews & Scientific Presentations** • Content: Interview techniques, presentation structure, visual aids. • **Activity**: Each student delivers a 3-minute scientific presentation with slides; teacher gives feedback.

16.	**Advanced Grammar – Complex Tenses in Scientific Writing** • Content: Present perfect, past perfect, future perfect in research contexts. • **Activity**: Students rewrite results sentences using appropriate tense.
17.	**Error Correction** • Content: Common errors in thesis writing & presentations. • **Activity**: Students are given an extract of a poorly written abstract → they correct errors in groups.
18.	**Pronunciation & Oral Fluency** • Content: Intonation, rhythm, clarity in spoken English. • **Activity**: Tongue-twister + technical word pronunciation practice in pairs.
19.	**GD/Presentation Practice Session** • Content: Applying all oral skills. • **Activity**: Half the class does a GD; other half presents 3-min talks. Feedback session.
20.	**Final Review & Practical Assessment** • Content: Integration of technical writing + communication skills. • **Activity**: Each student submits "review article outline" + gives a 2-minute oral summary.

Suggested Readings

- Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
- Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
- Collins' Cobuild English Dictionary. 1995.
- Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
- Holt, Rinehart and 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.
- Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
- Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Intellectual Property and its Management in Agriculture **PGS-503**
Credit Hrs.: 1(1+0)
Theory

S.No.	Topic	No. of Lecture
	Unit I	
1.	**Introduction and meaning of Intellectual Property**	**1**
2.	**GATT, WTO, TRIPS, Provisions in TRIPS Agreement**	**1**
3.	**Berne Convention, Madrid Protocol, Budapest Treaty**	**1**
4.	**Indian Legislation for the protection of various types of Intellectual Properties**	**1**

5.	**Fundamentals of patents**	**1**
	Unit II	
6.	**Copyrights**	**1**
7.	**Geographical Indications**	**1**
8.	**Designs and layout**	**1**
9.	**Trade secrets, Trademarks**	**1**
10.	Traditional knowledge- meaning and rights of TK holders	1
11.	Protectable subject matters, Integrated Circuits	1
12.	PPV & FR Act of India, Registration of Plant Varieties under PPV&FR Act 2001, Breeders, Researchers and Farmers Rights	2
	Unit III	
13.	Indian Biological Diversity Act 2002 and its salient features, access and benefit sharing, Convention on Biological Diversity	1
14.	Protection in biotechnology, protection of other biological materials	1
15.	International Treaty on Plant Genetic Resources for Food and Agriculture	1
16.	Licensing of technologies	1
17.	Material transfer agreements; Research Collaboration Agreement; License Agreement	1

Suggested Readings

- 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 and Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol.
- V. Technology Generation and IPR Issues. Academic Foundation.
- Rothschild M and 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; The Biological Diversity Act, 2002.

Basic Concepts in Laboratory Techniques **PGS-504**
Credit Hrs.: (0+1)
Practical

S. No.	Practical topics	No. of Lectures
1.	Laboratory Safety & Chemical Handling	1
2.	Laboratory Glassware & Their Uses	1

3.	Cleaning & Sterilization of Materials	1
4.	Drying of solvents/ chemicals;	1
5.	Weighing and preparation of solutions of different strengths and their dilution	1
6.	Handling techniques of solutions;	1
7.	Preparation of different agro-chemical doses in field and pot applications	1
8.	Preparation of solutions of acids; Neutralisation of acid and bases.	2
9.	Preparation of buffers of different strengths and pH values	1
10.	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath;	2
11.	Electric wiring and earthing	1
12.	Preparation of media and methods of sterilization;	1
13.	Seed viability testing, testing of pollen viability;	1
14.	Tissue culture of crop plants;	1
15.	Description of flowering plants in botanical terms (taxonomy orientation)	1
	Total	**17**

Suggested Reading

- Furr A K. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
- Gabb MH and Latchem W E. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Agricultural Research, Research Ethics and Rural Development Programmes
PGS-505 **Credit Hrs.: (1+0)**
Theory

S.No.	Contents of the lecture	No. of Lecture
	UNIT 1 **Global and National Agricultural Research Systems**	
1.	**History of agriculture in brief.**	1
2.	**Global agricultural research system: its need, scope, and opportunities.**	1
3.	**The role of the global agricultural research system in promoting food security, reducing poverty, and protecting the environment.**	1
4.	**Overview of National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions.**	1
5.	**Consultative Group on International Agricultural Research (CGIAR) and its role as a partner in the global agricultural research system.**	1
6.	**The role of International Agricultural Research Centres (IARC) and their partnership with NARS.**	1
7.	**Strengthening capacities at national and regional levels through international agricultural research systems.**	1
8.	**International fellowships for scientific mobility.**	1

	UNIT II **Research Ethics**	
9.	Introduction to research ethics and research integrity.	1
10.	Research safety in laboratories and the welfare of animals used in research.	1
11.	Computer ethics as a component of research ethics.	1
12.	Standards and common problems in research ethics.	1
	UNIT III **Rural Development**	
13.	The concept and connotations of rural development, Rural development policies and strategies.	1
14.	Community Development Programme, Intensive Agricultural District Programme, Special Group-Area Specific Programme, and the Integrated Rural Development Programme (IRDP).	1
15.	Roles of Panchayati Raj Institutions, Co-operatives, Voluntary Agencies, and Non-Governmental Organisations.	1
16.	A critical evaluation of rural development policies and programmes, and the constraints in their implementation.	1

Suggested Readings

- Bhalla GS and 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

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