

**Syllabus
For
Post Graduate Programme
M.Sc. (Ag.) & Ph. D.**

2014

FACULTY OF AGRICULTURE

**Compiled and Edited
by**

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**Dr. G.L.Keshwa
Dean & Chairman
Faculty of Agriculture**



**SRI KARAN NARENDRA AGRICULTURE
UNIVERSITY, JOBNER (JAIPUR)- 303329**



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FOREWORD

The ICAR constituted a National Core Group (NCG) to revise the course curricula and syllabi of Masters' and Doctoral programmes in all disciplines of Agriculture. The NCG further constituted 18 Broad Subject Matter Area Committees to undertake this exercise. The present syllabus is an adoption of new and restructured Post Graduate curricula and syllabi as recommended by ICAR. The curricula have been adopted by Sri Karan Narendra Agriculture University, Jobner since academic session 2009-10.

The revised curricula and syllabi contains lecture schedule for both theory and practical, list of relevant books for reference, list of related journals and websites for the benefit of students and teachers. I appreciate the efforts made by Heads of Departments of SKN College of Agriculture, Jobner and for giving their valuable input and preparing of lecture schedules. The efforts of Dr. G.L. Keshwa, Dean and Faculty Chairman, S.K.N. College of Agriculture, Jobner deserves appreciation for his timely action for publication of syllabi on behalf of the Sri Karan Narendra Agriculture University, Jobner. I compliment Dr. L.R. Yadav, Professor, Department of Agronomy for compiling and editing this valuable document which would prove useful for the teachers, students and the entire faculty of Agriculture of SKNAU, Jobner.

(Dr. Narendra S. Rathore)

Dated : July 9, 2014



**SKN COLLEGE OF AGRICULTURE
(SRI KARAN NARENDRA AGRICULTURE
UNIVERSITY)
JOBNER (JAIPUR) 303329 (RAJ.)**

Dr. G.L. Keshwa

Dean & Faculty
Chairman

PREFACE

The country has undergone a major transformation with respect to higher education at post-graduate level in agriculture. The Committee of experts comprising 18 Broad Subject Matter Area revised the post-graduate (Masters' and Doctoral) course curricula at country level in consultation with National Core Group of 12 academicians constituted by the ICAR. The present compilation of syllabus for post-graduate level contains lecture schedules for theory and practical classes, reference books & journals and websites for each course. Dr. L.R. Yadav, Professor, Department of Agronomy deserves appreciation for his commendable exercise in compiling this important document. All the Heads of the S.K.N. College of Agriculture, Jobner also deserves appreciation for their co-operation and assistance in preparation of this syllabus.

(Dr. G.L. Keshwa)

Dated : July 10, 2014

CONTENTS

S.No.	Name of Department	Page No.
1.	Agronomy	1-27
2.	Soil Science and Agricultural Chemistry	28-47
3.	Plant Breeding and Genetics	48-62
4.	Horticulture	63-80
5.	Entomology	81-95
6.	Plant Pathology	96-111
7.	Extension Education	112-125
8.	Agricultural Economics	126-141
9.	Agricultural Engineering	142-152
10.	Biochemistry and plant Physiology	153-164
11.	Live Stock Production and management	165-172
12.	Statistics	173-182

AGRONOMY

M.Sc. Programme

I Semester

Course No.	Course title	Credit hours
AGRON 511	Agrometeorology and crop weather forecasting	3(2+1)
AGRON 512*	Principles and practices of water management	3(2+1)
AGRON 513*	Principles and practices of soil fertility and nutrient management	3(2+1)

II Semester

AGRON 521*	Modern concepts in crop production	3(3+0)
AGRON 522*	Principles and practices of weed management	3(2+1)
AGRON 523	Dryland farming and watershed management	3(3+0)
AGRON 524	Cropping systems and sustainable agriculture	3(3+0)

III Semester ,M.Sc.(Ag)

AGRON 531	Agronomy of major cereals and pulses	3(2+1)
AGRON 532	Agronomy of oilseeds, commercial and fibre crops	3(2+1)

IV Semester

AGRON 541	M.Sc. Seminar	1(0+1)
AGRON 542	M.Sc. Comprehensive	2(0+2)
AGRON 543	M.Sc. Research	15

Ph.D. Programme

I Semester

AGRON 611*	Advances of crop growth and productivity	3(2+1)
AGRON 612*	Advances in weed management	3(3+0)

II Semester

AGRON 621	Irrigation management	3(2+1)
AGRON 622	Stress crop production	3(2+1)

III Semester

AGRON 641	Ph.D. Seminar	2(0+2)
AGRON 642	Ph.D. Preliminary	4(0+4)
AGRON 643	Ph.D Research	10

IV, V and VI Semesters,

AGRON 643	Ph.D Research	30
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Minor courses for M.Sc. and Ph.D. for the students of related disciplines as under :

Course No.	Course title	Credit hours
AGRON 513	Principles and practices of soil fertility and nutrient management	3(2+1)
AGRON 523	Dryland farming and watershed management	3(3+0)
AGRON 531	Agronomy of major cereals and pulses	3(2+1)

Minor and supporting/related courses for students of M.Sc.(Ag.) and Ph.D. (Agronomy)

M.Sc.(Ag.)

Supporting courses

i.	STAT 511	Statistical methods	3(2+1)
ii.	STAT 521	Experimental designs	3(2+1)

Minor courses

i.	SOILS 513	Analytical techniques and instrumental methods in soil and plant analysis	3(2+1)
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ii.	PPHYS 531	Hormonal regulation of plant growth and development	3(2+1)
iii	SOILS 532	Management of problem soils and waters	3(2+1)

Ph.D.

Supporting /related courses

i.	PPHYS 511	Principles of plant physiology	3(3+0)
ii.	PPHYS 521	Physiological and molecular responses of plants to abiotic stress	3(2+1)

Minor courses

i.	SOILS 524	Soil water and air pollution	3(2+1)
ii.	SOILS 511	Soil Chemistry	3(2+1)

Note: If required an another course (related / minor) running in a particular semester may also be offered.

* Core courses

AGRON 511 Agrometeorology and Crop Weather Forecasting 3(2+1)

Objective

To impart knowledge about agro-meteorology and crop weather forecasting to meet the challenges of aberrant weather conditions.

Theory:

Agro meteorology: aim, scope and development in relation to crop environment, composition of atmosphere, distribution of atmospheric pressure, Solar radiation : characteristics, energy balance of atmosphere system, radiation distribution in plant canopies, radiation utilization by field crops, photosynthesis and efficiency of radiation utilization by crops, energy budget of plant canopies, Environmental temperature: soil, air, canopy temperature, temperature profile in air, soil and crop canopies, soil and air temperature effects on plant processes, regulation of air, soil temperature for protection against frost and hot winds, Environmental moisture and evaporation, measures of atmospheric moisture, temperature, relative humidity, vapour pressure and their relationship, evapotranspiration and meteorological factors determining evapotranspiration, Modification of plant environment: artificial rain making, controlling heat load, heat trapping and shedding, protection from cold, reduction in sensible and latent heat flux, Monsoon: monsoon and their origin, characteristics of monsoon, onset and progress of monsoon, withdrawal of monsoon, Weather forecasting in India: short, medium and long range forecasting, benefits of weather service to agriculture, forecasting of destructive frost, soil moisture forecast, phenological forecast, crop yield forecast, Aero-space science and remote sensing : application in agriculture, present status of remote sensing in India, Atmospheric pollution and its effect on climate and crop production.

Practical

Agrometeorological observatory- classes, site selection, layout and installation of meteorological instruments; handling of meteorological instruments; measurement of weather parameters; working out agroclimatic indices; maintenances of record; calculation of daily, weekly and monthly means; visit to state remote sensing centre, Jodhpur/Jaipur; measurement of soil temperature in different soil conditions/depths; interpretation and use of weather data; rainfall analysis for variability; moisture availability indices for an arid and a humid district, length of growing season, fitting cropping systems; preparation of weather maps, synoptic charts and weather reports; preparation of crop weather calendars, to become familiar with agro advisory service bulletins visit to ARS, Durgapura/Bikaner.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
1	Agro meteorology - aim, scope and development in relation to crop environment	2
2	Composition of atmosphere, distribution of atm. pressure	1
3	Solar radiation - characteristics	1
4	Energy balance of atmosphere system	1
5	Radiation distribution in plant canopies, radiation utilization by field crops	2
6	Photosynthesis and efficiency of radiation utilization by crops	2
7	Energy budget of plant canopies	1
8	Environmental temperature- soil, air, canopy temperature, temperature profile in air, soil,	2

	crop canopies	
9	soil and air temperature effects on plant processes	2
10	Regulation of air, soil temperature for protection against frost and hot winds	2
11	Environmental moisture and evaporation - measures of atmospheric moisture, temperature, relative humidity, vapour pressure and their relationship	2
12	Evapotranspiration and meteorological factors determining evapotranspiration	2
13	Modification of plant environment, artificial rain making, controlling heat load, heat trapping and shedding	2
14	Protection from cold, reduction in sensible and latent heat flux	1
15	Monsoon and their origin, characteristics of monsoon	1
16	Onset and progress of monsoon withdrawal of monsoon	1
17	Weather forecasting in India: short, medium and long range forecasting	2
18	Benefits of weather service to agriculture, forecasting of destructive frost, soil moisture forecast, phenological forecast, crop yield forecast etc	2
19	Aero-space science and remote sensing - application in agriculture, present status of remote sensing in India.	2
20	Atmospheric pollution and its effect on climate and crop production	1

Lecture schedule- Practical

S. No.	Topic	No. of lectures
1	Agro meteorological observatory – classes, site selection, layout and installation procedures for meteorological instruments	1
2	Handling of meteorological instruments	1
3	Measurement of weather parameters	1
4	Working out agro climatic indices	1
5	Maintenance of records	1
6	Calculation of daily, weekly and monthly means	2
7	Visit to state Remote Sensing Centre, Jodhpur/Jaipur	1
8	Measurement of soil temperature in different soil conditions/depths	1
9	Interpretation and use of weather data	1
10	Rainfall analysis for variability	2
11	Moisture availability indices for an arid district	1
12	Moisture availability indices for a humid district	1
13	Length for growing season, fitting cropping systems	1
14	Preparation of weather maps, synoptic charts & weather reports	1
15	Preparation of crop weather calendar	1
16	To become familiar with Agro-advisory-service bulletins/	1

Suggested Readings:

- S. Mavi (1994). Introduction to Agrometeorology. Oxford & IBH Publishing Co. New Delhi.
- P.A. Menon (1989). Our weather. National Book Trust, New Delhi.
- A.A. Rama Sastu (1984). Weather and Weather forecasting Publication Division, GOI.
- P.K. Das (1992). The Monsoon. National Book Trust, New Delhi.
- S. Venkateraman and A. Krishnan. Crops and Weather. Indian Council of Agricultural Research, New Delhi.
- Critchfield, H.J. 1995. General Climatology, Prentice Hall of India Pvt. Ltd., New Delhi
- R.S. Gena and S.P. Seetharaman (1991). Natural Resource Management: The Role of Remote sensing in decision making. Oxford & IBH Publishing Co. New Delhi.
- K.L. Joshi, Sinha and D.P. Gupta (1985). Physical Geography, National Council of Educational Research and Training, New Delhi.
- Vasiraju Radha Krishna Murthy (1995). Practical Manual on Agricultural Meteorology, Kalyani Publishers, Ludhiana.
- D.S. Lal, 1998. Climatology. Sharda Pustak Bhawan.
- S.R. Ghadekar, 1991. Meteorology, Agromet Publishers, Nagpur.
- A.K. Sacheti, 1985. Agricultural Meteorology- Instructional-cum-Practical Manual. NCERT, New Delhi.
- Mavi H.S. and Tuper G.J. 2004. Agrometeorology: Principles and Application of Climate Studies in Agriculture. Haworth Press.
- Vashneya M.C. and Balakrishana Pillai P. 2003. Textbook of Agricultural Meteorology, ICAR.

AGRON 512**Principles and Practices of Water Management****3(2+1)****Objective**

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

Theory:

Water, its properties and role in plants; Water resources of India, Major irrigation projects and extent of area and crops irrigated in India; Water potential – concept, components and relationship between different components; Water movement in plant and soils; Absorption and transpiration of water in plants; Scheduling and methods of irrigation including micro irrigation system; Fertigation, Water use efficiency: Water management of crops and cropping systems; Soil, plant and meteorological factors determining water needs of crops; Water deficit stress in plants and its effect on growth. Quality of irrigation water – effect of saline water and soil salinity on plants and its management, Excess soil water and plant growth; Water management in problem soils; Drainage requirement of crops and methods of drainage, their layout and spacing.

Practical:

Determination of soluble salts, Ca + Mg, CO₃²⁻ and HCO₃⁻ and Na in irrigation water; Determination of FC and PWP; Soil moisture measurement by tensiometer and pressure plate apparatus; Water flow measurement using different devices. Determining soil profile moisture deficit and irrigation requirement. Calculations on irrigation efficiencies; Computation of water requirement of crops using modified Penman formula. Determination of infiltration rates and hydraulic conductivity.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
1	Water, its properties and role in plants	2
2	Water resources of India, major irrigation projects, and extent of area and crops irrigated in India	3
3	Water potential-concept, components and relationship between different components	2
4	Water movement in plants and soils	2
5	Absorption-types and relative importance	2
6	Transpiration – types and methods to reduce transpiration	2
7	Scheduling of irrigation and methods of irrigation including micro irrigation system, fertigation	2
8	Water use efficiency and factors affecting it	2
9	Water management of crops and cropping systems	2
10	Soil, plant and meteorological factors determining water needs of crops	2
11	Water deficit stress in plants and its effect on growth	2
12	Quality of irrigation water-criteria used, effect of poor quality water on plant growth and management of saline water for irrigation	3
13	Excess soil water and plant growth	2
14	Water management in problem soils	2
15	Drainage requirement of crops and methods of drainage, their layout and spacing	2

Lecture schedule- Practical

S. No.	Topic	No. of lectures
1	Determination of soluble salts and Ca + Mg in irrigation water	1
2	Determination of CO ₃ ²⁻ and HCO ₃ ⁻ and Na in irrigation water	1
3	Determination of FC and PWP	2
4	Determination of soil moisture by tensiometer and pressure plate apparatus	2
5	Water flow measurement using different devices	2
6	Determining soil profile moisture deficit	1
7	Determination of irrigation requirement of crops	2
8	Calculations on irrigation efficiencies	2
9	Computation of water requirement of crops using modified Penman formula	1
10	Determination of infiltration rate of soil	1
11	Determination of hydraulic conductivity of soil	1

Suggested Readings:

A.M. Michael, 1987. Irrigation – Theory and Practice, Vikas Publishing House Pvt. Ltd., New Delhi
 S.S. Parihar and B.S. Sandhu, 1978. Irrigation of field crops – Principles and Practices, ICAR, New Delhi
 D. Lenka, 1999. Irrigation and Drainage. Kalyani Publishers, New Delhi.

- R.D. Mishra and M. Ahmed. 1987. Manual on Irrigation Agronomy, Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi
- G.H. Sankara Reddy and T. Yellamanda Reddy. 1995. Efficient use of irrigation water. Kalyani Publishers, New Delhi
- K.V. Paliwal. 1972 Irrigation with saline water WTC, IARI, New Delhi.
- I.C. Gupta 1990. Use of saline water in Agriculture. Oxford & IBH Pub. Co. Ltd., New Delhi
- P.J. Kramer and J.S. Boyer 1995. Water relations of Plants & Soils, Academic Press, California, USA.
- S.R. Reddy 2000. Principles of Crop Production, Kalyani Publication, New Delhi.
- D.K. Majumar 2004. Irrigation water management – principles and practice, Prentice Hall of India, New Delhi.
- S.C.Panda 2003. Principles and practices of water management. Agrobios, Jodhpur
- Singh Pratap and Maliwal P.L. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Pubc.

AGRON 513 Principles and Practices of Soil Fertility and Nutrient Management 3(2+1)

Objective

To impart knowledge of soil fertility and plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil resources.

Theory:

Problems and management relating to mechanical impedance and soil submergence; Salt affected soils - problems and remedial measures; Soil acidity and remedial measures; Soil fertility and productivity concept and differences: Criteria of essentiality and forms in which nutrients are absorbed by plants; Physiological methods of increasing FUE. **Nitrogen:** Functions, deficiency and toxicity symptoms, forms of nitrogen, nitrogen transformation in soil, organic and mineral N balance in soil, mineralization of N compounds, losses of N from soil, nitrogenous fertilizer materials. Methods to increase N use efficiency and slow release fertilizers; Biological N fixation, symbiotic and free living N fixers; **Phosphorus:** Functions and deficiency symptoms, forms of P in soil, their availability and P fixation, various phosphatic fertilizers; Practices of increasing the effectiveness of applied and native phosphorus (PSB). **Potassium:** Functions and deficiency symptoms, forms of K in soil, fixation and release of potassium in soil; Potassic fertilizers and their application. Sulphur and micronutrients (Fe, Zn) functions, deficiency symptoms and application; Inter relationship of nutrient availability and soil pH; Important nutrient interactions and their effect on nutrient availability, cation exchange capacity and availability of plant nutrients; Integrated nutrient management.

Practical:

Procedure of plant and soil sampling; Determination of soil pH, EC and organic carbon; Determination of total N and available N, P and K in soils; Determination of N, P, K and S in plant samples; Determination of Ca, Mg and Na in soil; Determination of gypsum requirement of alkali soils.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
1	Soil problems relating to mechanical impedance and their management / remedial measures	1
2	Soil submergence - meaning, causes and electro chemical changes occurring (oxidized-reduced zones and redox potential)	2
3	Salt affected soils – characteristics, classification and their remedial measures	2
4	Soil acidity-characteristics, reasons of soils acidity and remedial measures/ amelioration	2
5	Soil fertility and productivity concept and differences	1
6	Criteria of essentiality and forms in which nutrients are absorbed by plant.	2
7	Physiological methods of increasing FUE	1
8	Nitrogen:	
	Functions, deficiency and toxicity symptoms, forms of nitrogen, N – transformation in soil, organic and mineral nitrogen balance in soil, mineralization of N compounds and factors affecting nitrification, losses of N from soil.	4
	N-fertilizers, slow release fertilizers and methods to increase nitrogen use efficiency	1
	Biological nitrogen fixation, symbiotic and free living N fixers	2
9	Phosphors	
	Functions and deficiency symptoms, forms of P in soil and their availability, P	2

	availability in relation to pH, P-fixation.	
	Various P fertilizers and practices of increasing the effectiveness of applied and native phosphorus (PSB)	2
10	Potassium:	
	Functions and deficiency symptoms, forms of K in soil, fixation and release of K in soils, factors affecting K availability	3
	Potassic fertilizer and their application	1
11	Sulphur and micronutrients (Fe & Zn) – functions, deficiency symptoms and application	2
12	Interrelationship of nutrient availability and soil pH	1
13	Important nutrient interactions and their effect on nutrient availability, cation exchange capacity and availability of plant nutrients	2
14	Integrated nutrient management concepts	1

Lecture schedule- Practical

S. No.	Topic	No. of lectures
1	Procedure of plant and soil sampling	1
2	Determination of soil pH, ECE and organic carbon	3
3	Determination of total N and available N, P and K in soil	4
4	Determination of total N, P, K and S in plant samples	4
5	Determination of Ca, Mg and Na in soil	2
6	Determination of gypsum requirement of alkali soils	2

Suggested Readings:

1. S.L. Tisdale, W.L. Nelson, J.D. Beaton and J.L. Havlin. 1997. Soil Fertility and Fertilizers. Prentice Hall of India, Pvt. Ltd., New Delhi
2. T.R. Reddy and G.H.S. Reddi 1992. Principles of Agronomy, Kalyani Publishers, New Delhi
3. L.A. Richards, 1968. Diagnosis and Improvement of Saline and Alkali Soils, Oxford and IBH Publishing Company, New Delhi
4. Tamhaney, Motiramani, Bali and Donahu, 1970. Soils Their Chemistry and Fertility in Tropical Asia, Prentice Hall of India, New Delhi
5. R.R. Agarwal, J.S. P. Yadav and S.N. Gupta, 1982. Saline and Alkalai soils of India. ICAR Publication, New Delhi
6. G.Singh, J.S. Kolar and H.S. Sekhon, 2002. Recent Advances in Agronomy, Indian Society of Agronomy, IARI, New Delhi
7. J.S. Kanwar, 1978. Soil Fertility: Theory and Practices, ICAR Publication, New Delhi
8. J.L. Havlin, J.D. Beaton, S.L. Tisdale and W.L. Nelson, 2006. Soil Fertility and Fertilizers- An Introduction to Nutrient Management, Prentice Hall of India, Pvt. Ltd., New Delhi
9. N.C. Brady and R.R. Weil, 2003. Elements of the Nature and Properties of Soils. Prentice Hall, New Jersey.
10. R.S. Yawalkar, J.P. Agarwal and J. Bokde 1992. Manures and Fertilizers. Agri-Horticultural House, Nagpur
11. N.K. Fageria, V.C. Baligar and C.A. Jones 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker, New York.

AGRON 521

Modern Concepts in Crop Production

3(3+0)

Objective

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

Theory:

Agronomic aspects in food security; Crop growth and production in relation to climate change; Agro ecological and agroclimatic zones of India; Concept of potential yield; Modern concepts in tillage- zero, minimum and conservation tillage; Optimization of plant population and planting geometry in relation to soil fertility, solar radiation and available moisture regimes; Mitscherlich, Baule and Inverse yield : nitrogen laws; Biotic and abiotic stresses; Concept of ideal plant type; Organic farming, Physiology of grain yield in cereals; Crop growth analysis; Crop modelling in agronomic systems; Precision agriculture; Growth regulators and their role in agriculture; Designer crops; Vermi-technology; Agro biodiversity; Seed priming; ; Indigenous technological knowledge; Herbicide resistance in weeds; Allelopathy in agriculture ; Plant nutrition and disease tolerance in field crops.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
1	Population and food requirement	1
2	Agronomic techniques for food security, crop nutrition, value addition	2
3	Effect of climate change on crop production	1
4	Direct and interactive effect of different climatic parameters on crop production	2
5	Agroecological and agroclimatic zones of India and their introduction	2
6	Concept of potential yield	1
7	Introduction to modern concepts of tillage- zero tillage minimum tillage, furrow irrigated raised bed system, resource conservation	3
8	Conservation tillage - its advantages, disadvantages , types and Methods	1
9	Relationship between plant population and yield and response curves	1
10	Optimum plant population in relation to soil fertility and solar radiation	1
11	Mitscherlich equation, Baule unit and inverse yield: nitrogen laws	2
12	Abiotic and biotic stresses	2
13	Definition and concept of ideal plant type	1
14	Characteristics of an ideotype plant for dryland agriculture	1
15	Ideotype plant for wheat	1
16	Organic farming – definition, differences between conventional and organic farming and principles and components of organic farming	2
17	Physiology of grain yield in cereals	2
18	Growth curves and analysis of crop growth : LAI, CGR, RGR, NAR, LAD	2
19	Crop model-definition, concept and types (empirical & mechanistic)	1
20	Scientific basis of modelling	1
21.	Model applications	1
22	Precision agriculture-definition, basic concept, scope and approach	1
23.	Technologies for precision agriculture: computers, geographical information system (GIS), global positioning, system (GPS), sensors, etc.	2
24.	Plant growth regulators-definition,types and their role in crop Production	2
25	Designer crops - concept and importance	2
26	Vermi- technology , meaning, methods and scope	2
27	Agro- biodiversity- definition, effects, threats and conservation	2
28	Seed priming- concept, importance and use in crop production	1
29	Indigenous technological knowledge and its use in crop production	1
30	Herbicide resistance in weeds – meaning and management of resistant weeds	2
31	Allelopathy in agriculture	1
32	Plant nutrition and disease tolerance in field crops	1

Suggested Readings:

1. Gardner, F.P.;Pearce, G.R. and Michell, R.I. Physiology of Crop Plants, Scientific Pub., Jodhpur.
2. S.P. Palaniappan and Shivarama,K. 1996. Cropping Systems in the Tropics - Principles and Management. New Age International Pub.
3. Fageria, N.K. 1992. Maximising crop yields. Marcel Dekker, New York.
4. Reddy,S.R. 2000. Principles of Agronomy. Kalyani Pub. New Delhi.
5. Sankaran, S. and Mudaliar ,T.V.S. 1997. Principles of Agronomy. The Bangalore Printing and Pub. Bangalore.
6. Redford, J. 1967. Growth Analysis formulae: Their use and abuse. Crop Science. 76:171-175.
7. Singh, G.; Kolar, J.S. and Sekhon, H.S. 2002 Recent Advances in Agronomy (Ed). ISA, Publication, New-Delhi.
8. Paroda, R.S. 2003. Sustaining Our Food Security. Konark Publishers Pvt. Ltd., Delhi
9. Balasubrammanian P. and Palaniappan, S.P. 2001. Principles and Practices of Agronomy. Agrobios
10. Havlin J.L., Beaton J.D., Tisdale S.L. and Nelson W.L. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.

AGRON 522 Principles and Practices of Weed Management**3(2+1)****Objective**

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

Theory

Weed–biology, ecology and classification; history, development and classification of herbicides, their properties, mode of action and uses, basis of selectivity of herbicides; herbicide mixtures, adjuvants and safeners; weed control principles and management practices in important grain crops, oilseeds, pulses, sugar, fibre crops, tuber crops and forage crops; vegetables and orchards; weed control under specific situations viz. intercropping systems, non cropped areas and drylands; noxious farm weeds and parasitic weeds and their control; fate of herbicides in soil; herbicide - pesticides and fertilizer interactions; allelopathic effect; integrated weed management; problem of aquatic weeds particularly water hyacinth, hydrilla and typha grass in Rajasthan and their possible control measures; weed control through bio herbicides and myco- herbicides; herbicide resistance in weeds and crops.

Practical :

Identification of common *kharif*, *rabi* and perennial weeds of crop fields, road sides, waste lands and irrigation channels; familiarization with trade names, common names, uses, cost and source of availability of herbicides; calibration of sprayer and maintenance (before and after use); study of different herbicidal formulations; calculation on herbicidal requirement for field crops and aquatic situation; application of herbicides in field crops; control of some noxious weeds by cultural and chemical means; study on weed control efficiency and calculation on weed infestation and weed index; preparation of weed herbarium, methodology for weed control research and precautions in handling or storage of herbicides.

Lecture schedule – Theory

S. No.	Topic	No. of lectures
1	Weeds- biology, ecology and classification	2
2	Herbicides -	2
	a) History, development and classification of herbicides	2
	b) Properties of herbicides	2
	c) Mode of action and uses of herbicides	2
	d) Basis of selectivity of herbicides	2
3	Herbicide mixtures, adjuvants and safeners	2
4	Weed control principles and management practices in important crops	1
	a) Grain crops	2
	b) Oilseeds and pulses	2
	c) Sugar and fibre crops	1
	d) Tuber and forage crops	2
	e) Vegetable crops	2
	f) Orchards	1
5	Weed control under specific situations – intercropping system, drylands and non cropped area	1
6	Noxious farm weeds, parasitic weeds and their control	1
7	Fate of herbicides in soil	2
8	Herbicide- pesticides and fertiliser interactions	1
9	Allelopathic effects	1
10	Integrated weed management	1
11	Problem of aquatic weeds particularly water hyacinth, hydrilla and typha grass in Rajasthan and their possible control measures	1
12	Weed control through bio-herbicides and myco- herbicides	1
13	Herbicide resistance in weeds and crops	1

Lecture schedule-Practical

S. No.	Topic	No. of lectures
1	Identification of common <i>Kharif</i> and <i>Rabi</i> weeds	1
2	Identification of perennial weeds of crop fields, road sides, wastelands and irrigation channels	1
3	Familiarization with trade names, common names, uses, cost and sources of availability of herbicides	1

4	Calibration of sprayers and maintenance (before and after use)	1
5	Study of different herbicidal formulations	1
6	Calculation on herbicidal requirement for field crops under aquatic situations	2
7	Application of herbicides in field crops	2
8	Control of some noxious weeds by cultural and chemical means	1
9	Study on weed control efficiency and calculation on weed infestation and weed index	2
10	Preparation of weed herbarium	2
11	Methodology for weed control research	1
12	Precautions in handling or storage of herbicides	1

Suggested Readings :

- Aldrich RJ & Kramer RJ. 1997. *Principles in Weed Management*. Panima Publ.
 Ashton FM & Crafts AS. 1981. *Mode of Action of Herbicides*. 2nd Ed. Wiley Inter-Science.
 Gupta OP. 2007. *Weed Management – Principles and Practices*. Agrobios.
 Mandal RC. 1990. *Weed, Weedicides and Weed Control - Principles and Practices*. Agro-Botanical Publ.
 Rao VS. 2000. *Principles of Weed Science*. Oxford & IBH.
 Subramanian S, Ali AM & Kumar RJ. 1997. *All About Weed Control*. Kalyani.
 Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic. Press

AGRON 523 Dryland Farming and Watershed Management

3(3+0)

Objective

To teach the basic concepts and practices of dryland farming, soil moisture conservation and watershed management.

Theory:

Definition, concept, significance and dimensions of dryland farming in Indian agriculture, characteristics of dryland farming and dryland versus rainfed farming; constraints limiting crop production in dry land areas; characterisation of environment for water availability; delineation of dry farming areas on the basis of moisture deficit index and their characteristics, use of mulches, kinds, effectiveness and economics; antitranspirants- their types, mechanism and role in dry farming; water harvesting- its concepts, techniques and practices; soil and crop management techniques- tillage, seeding, fertilizer use, crop and varietal choice, cropping system, weed control and other management practices; plant ideotypes for drylands, drought management strategies; preparation of appropriate crop plans for dryland areas; mid season corrections for aberrant weather conditions. Watershed management- definition, objectives, concepts, problems, approach components, development of cropping systems for watershed areas; alternate land use systems; planning and operation of project for watershed management.

Lecture Schedule- Theory

S. No.	Topic	No. of Lectures
1	Dryland farming- definition, concept, significance and dimensions of dryland farming in India agriculture	3
2	Characteristics of dryland farming and dryland versus rainfed farming	3
3	Constraints limiting crop production in dry land areas	3
4	Characterisation of environment for water availability	3
5	Delineation of dry farming areas on the basis of moisture deficit index and their characteristics,	3
6	Use of mulches, kinds, effectiveness and economics	3
7	Antitranspirants- their types, mechanism and role in dry farming	3
8	Water harvesting, its concepts, techniques and practices	3
9	Soil and crop management techniques- tillage, seeding, fertilizer use, crop and varietal choice, cropping system, weed control and other management practices	5
10	Plant ideotypes for drylands	2
11	Drought management strategies	3
12	Preparation of appropriate crop plans for dryland areas	2
13	Mid season corrections for aberrant weather condition	2
14	Watershed management- Definition, objectives, problems, approach and components	3
15	Development of cropping system for watershed areas	3

16	Alternate land use systems	3
17	Planning and operation of project for watershed management	3

Suggested Readings:

- R.P. Singh, Srinivas Sharma, M.V. Padmanabhan, S.K. Das and P.K. Mishra, 1990. A Field Manual on Watershed Management, ICAR (CRIDA) Publication, Hyderabad.
- S.C. Verma and M.P. Singh. 1984. Agronomy of New Plant Types. Tara Book Agency, Varanasi.
- S. Palaniappan. 1985. Cropping Systems in Tropics: Principles and Management, Wiley Eastern Ltd., New Delhi & TNAU, Coimbatore.
- Mahendra Pal, K.A. Singh and I.P.S. Ahlawat. 1985. Cropping System Research I & II. In processing of the National Symposium on Cropping Systems Published by ISA, New Delhi.
- Efficient Crop Management in Dry Farming Areas. 1985. ICAR (CRIDA) Publication, Hyderabad.
- R.D. Asana, 1968. Growth Habit & Crops of Non-Irrigated Areas, Important Characters of Plant Types, Ind. Farming, 81:25-27.
- U.S. Gupta, 1975. Physiological Aspect of Dryland Farming, Oxford & IBH, New Delhi.
- T.Y. Reddy and C.H. Shankara Reddi. 1992. Principles of Agronomy, Kalyani Publishers, New Delhi.
- V.V. Dhurva Narayan, R.P. Singh, S.P. Bhardwaj, M., Sharma, A.K. Sikka, K.P.R. Vittal and S.K. Das. 1987. Watershed Management for Drought Mitigation, ICAR Publication, New Delhi.
- U.S. Gupta. 1995. Production and Improvements of Crops for drylands, Oxford & IBH Publishing Co. Ltd, New Delhi
- J.C. Katyal and J. Farrington, 1995. Research for Rainfed Farming, CRIDA, Hyderabad.
- P. Ramaswamy, 1982. Dry farming technology in India. Agricole Publishing Academy, New Delhi.
- S.D. Singh, Water harvesting in Desert, Manak Publication, New Delhi.
- R.P. Singh 1995. Sustainable Development of Dryland Agriculture in India, Scientific Publishers, Jodhpur.
- N.R. Das, 2007. Tillage and crop production. Scientific Publishers, Jodhpur
- S.C. Rao and J. Ryan 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publishers., Jodhpur

AGRON 524 Cropping Systems and Sustainable Agriculture 3(3+0)

Objective

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

Theory:

Cropping systems- intercropping and multiple cropping, concepts, needs, indices and assessment; existing cropping systems under irrigated and rainfed situations. Cropping system indices viz., relative spread index and relative yield index. Farming system: integrated farming system, alternate farming system - meaning and scope including specific examples. Recycling and crop residue management. Natural farming - concept and components. Organic farming. Crop diversification – principles, types and needs, Sustainable agriculture - definition, scope and objectives, Natural resources, their characterization and management; Sustainable cropping and farming systems in agriculture in relation to environmental degradation; Research needs on sustainable agriculture.

Lecture schedule – Theory

S. No.	Topic	No. of lectures
1	Cropping systems – definition and types	2
2	Intercropping – concept, needs, types, indices and assessments	3
3	Multiple cropping - concept and needs, Types, selection of crops and computation of indices	6
4	Cropping systems under irrigated conditions	5
5	Cropping systems for rainfed situation	2
6	Cropping system indices - relative spread index and relative yield index	2
7	Farming systems - integrated farming systems; definition, its components and IFS models	3
8	Alternate farming systems – meaning, scope and specific examples	3
9	Recycling and crop residue management	2
10	Natural farming – concept and components	2
11	Organic farming - definition, concept and components	2
12	Relevance of organic farming in present context its certification and accreditation	3
13	Crop diversification – principles, types and needs	3

14	Sustainable agriculture – definition, scope and objectives	2
15	Natural resources – their characterization and management	3
16	Sustainable cropping and farming systems in relation to environmental degradation	3
17	Research needs on sustainable agriculture	2

Suggested Readings:

- K.N. Singh and R.P. Singh (Eds), 1990. Agronomic Research Towards Sustainable Agriculture, Indian Society of Agronomy, New Delhi
- R.P. Singh, 1990. Sustainable Agriculture: Issues ,Perspectives and Prospects in Semi Arid Tropics. Vol I & II Indian Society of Agronomy, New Delhi
- Proceedings of the National Symposium on Cropping Systems 1985. Indian Society of Agronomy, New Delhi
- R.M. Devlin and E.H. Watham. 1986. Plant Physiology. CBS Publishers and Distributors, New Delhi.
- L.L.Somani, K.L. Totawat and B.L. Baser. 1992 (Ed.) Proceedings of National Seminar on Natural Farming, NSMP Publication, Rajasthan College of Agriculture, Udaipur
- K. Balakrishnan Nair, U.N. Goswami and K. Kunhkrishnan 1972 (Ed.) Proceedings of the Symposium on Cropping Patterns in India. ICAR Publication, New Delhi.
- R.W. Willey 1979. Intercropping: Its Importance and Research Needs, Field Crop Abstracts 332:1-10 & 73-81
- S.C. Panda. 2004. Cropping Systems and Farming Systems. Agrobios (India) Jodhpur
- Guriqbal Singh, J.S. Kolar and H.S. Sekhon 2002. Recent Advances in Agronomy, Indian Society of Agronomy, IARI, New Delhi
- Singh, S.S. 2006. *Principles and Practices of Agronomy*. Kalyani Publishers, Ludhiana.

AGRON 531

Agronomy of Major Cereals and Pulses

3(2+1)

Objective

To teach the crop husbandry of major cereals and pulses.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of rice, wheat, maize, barley, sorghum, pearl millet, chickpea and pigeon pea.

Practical

Phenological studies at different growth stages of crops, different methods of raising nursery including dapog in rice; estimation of crop yields on the basis of yield attributes; calculation of fertilizer requirements and their application at different stages of growth on the basis of soil test values; computation of cost of cultivation of various crops, planning and layout of field experiments, formulation of cropping scheme for various farm sizes, calculation of cropping and rotation intensities, visit of field experiments for cultural, fertilizer, weed control and water management aspects; working out indices of intercropping systems – L.E.R. aggressivity, relative crowding coefficient and monetary yield advantage, ATER; determination of physiological maturity in different crops; working out of harvest index in various crops; computation of growth analysis indices. Study of root nodules and seed treatment with bio-fertilizers in pulses, Estimation of protein in pulses.

Lecture schedule – Theory

S. No.	Topic	No. of lectures
1	Rice: Importance, production, distribution and classification, Cropping systems, agronomy of hybrid rice and climate, Climate, soil and cultural requirements and improved varieties, Nutrient, water and weed management in relation to latest research, Crop protection, handling and processing of produce, quality components and industrial uses of main and by products.	5
2	Wheat: Importance, production, distribution and classification,Cropping systems, adaptability in different agro climatic zones, climate and improved varieties, Soil and cultural requirements ,Nutrient, water and weed management in relation to latest research, Crop protection, handling and processing of produce.	5
3	Maize: Importance, production, distribution, cropping systems and classification, Adaptability in different agro climatic zones, climate, soil and cultural requirements and improved varieties, Nutrient, water and weed management in relation to latest research, Crop protection, handling and processing of produce, Prospects of <i>rabi</i> maize cultivation	5

	in India and its package.	
4	Barley: Importance, production, distribution, classification and cropping systems, Adaptability in different agro-climatic zones, climate, improved varieties, soil and cultural requirements Nutrient, water and weed management, Crop protection, handling and processing of produce, quality components and industrial uses of the main and by products.	3
5	Sorghum : Importance, production, distribution and cropping systems, Adaptability in different agro-climatic zones, climate, improved varieties, soil and cultural requirements, nutrient, weed and water management in relation to latest research, Crop protection, handling and processing of produce, quality components and industrial uses of the main and by products	4
6	Pearl millet : Importance, production, distribution and adaptability in different agroclimatic zones, Cropping systems, climate, improved varieties, soil and cultural requirements for maximization of production, Nutrient, weed and water management in relation to latest research, Plant protection, handling and processing of produce, quality components and industrial uses of the main and by products.	4
7	Chickpea :Importance, origin, production and distribution, classification, morphology and phenology, cropping systems, adaptability, Climate, soil and cultural requirement for maximization of production and improved varieties, Nutrient water and weed management, crop protection, handling and processing of produce.	3
8	Pigeon pea :Importance, origin, protection and distribution, classification, morphology and phenology, cropping systems, Adaptability, climate, soil and improved varieties, Nutrient, water and weed management, crop protection, handling and processing of produce.	3

Lecture Schedule - Practical

S.No	Topic	No. of lectures
1	Phenological studies at different growth stages of crops	1
2	Methods of raising nursery including dapog in paddy	1
3	Calculation of fertilizer requirements on the basis of soil test values	1
4	Computation of cost of cultivation in crops	1
5	Formulation of cropping schemes for various farm sizes and calculation of cropping and rotation intensities	2
6	Planning and layout of field experiments	1
7	Working out of indices of intercropping systems – LER aggressivity, relative crowding coefficient, monetary yield advantage and ATER	1
8	Determination of physiological maturity in different crops	1
9	Working out of harvest index in various crops	1
10	Computation of growth analysis indices	1
11	Visit of field experiments on cultural, fertilizer, weed control and water management aspects	1
12	Study of yield attributing characters of cereals and pulses, computation of yield on the basis of yield attributing characters.	1
13	Study of pattern and morphology of root nodules in pulses and seed treatment of pulses and grain legumes with Rhizobium culture	1
14	Estimation of protein in pulses	1
15	Interculture operations in various crops	1

Suggested Readings :

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Hunsgi G & Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.
- Khare D & Bhale MS. 2000. *Seed Technology*. Scientific Publ.
- Kumar Ranjeet & Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
- Pal M, Deka J & Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGrawHill.
- Prasad, Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
- B.N. Chatterjee and K.K. Bhattacharya, 1986. *Principles and Practices of Grain Legume Production*, Oxford & IBH Publishing Company, New Delhi.

Jeswani and Baldev, 1990. *Advances in Pulse Production Technology*, ICAR Publication, New Delhi.
 Singh C., Singh Prem and Singh Rajbir, 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH Publishing Co., New Delhi.
 Singh, SS. 1998. *Crop Management*. Kalyani publishers
 P.S. Rathore 2000. *Techniques and Management of Field Crop Production*. Agrobios (India) Jodhpur.
 D.S. Yadav, 1992. *Pulse Crops*, Kalyani Publishers, New Delhi.

AGRON 532 Agronomy of Oilseeds, Fibre and Commercial Crops 3(2+1)

Objective

To teach the crop husbandry of oilseed, fibre and commercial crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and processing of the produce for maximum production of oilseeds - groundnut, rapeseed and mustard and soybean; fibre crops - cotton and jute and commercial crops-sugarcane and potato.

Practical

Phenological studies at different growth stages of crops, study of yield attributing characters of oilseeds and cotton; computation of yield on the basis of yield attributing characters; determination of protein and oil content in oilseeds, Seed treatment of cotton seed with sulphuric acid and cow dung; computation of cost of cultivation of various crops; determination of quality of cotton including ginning per cent and lint index; calculation of fertilizer requirements and their application at different growth stages in various crops on the basis of soil test values.

cutting of cane setts, its treatment and method of sowing, tying and propping of sugarcane; determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in juice; preparation of blue print for sugarcane, calculation of seed rate and fertilizer requirement for sugarcane; to work out the cost of cultivation of sugarcane; selection of potato seed, its treatment and method of sowing; calculation of seed rate and fertilizer requirement for potato; preparation of blue print for potato.

Lecture schedule – Theory

S.No.	Topic	No. of lectures
1	Groundnut: Importance, origin, history, production and distribution, classification, morphology, branching, cropping systems, Adaptability, climate, soil and cultural requirement for maximization of production and improved varieties, Nutrient, water and weed management in relation to latest research, pegging, Crop protection, handling and processing of produce, quality components.	4
2	Rapeseed and mustard : Importance , origin, history, production and distribution, classification, morphology, cropping systems, Adaptability, climate, soil and cultural requirements and improved varieties, Nutrient, water and weed management , Crop protection, handling and processing of produce, quality components	3
3	Soybean : Importance, origin, history, production and distribution, cropping systems, adaptability, climate, soil and cultural requirement for maximization of production and improved varieties, Nutrient water and weed management, Crop protection, handling and processing of produce, quality components.	3
4	Cotton : Importance, origin, history, production and distribution, classification, morphology, branching, cropping systems, Adaptability, climate, soil and cultural requirements for maximization of production and improved varieties. Nutrient, water and weed management in relation to latest research. Crop protection, handling and processing of produce, fibre quality, boll shedding and correction, BT cotton	4
5	Jute : Importance, origin, history, production and distribution, classification, morphology, Adaptability, climate, soil and cultural requirement and improved varieties, Nutrient, water and weed management ,crop protection, harvesting, retting and extraction.	3
6	Sugarcane: Origin, history, importance, distribution and adaptation, Classification, morphology and phenology , General production constraints and varietal improvement, climate, soil, sowing methods and Seed treatment Fertilizer management and Crop logging, Intercultivation, irrigation and weed control,	9

	ripening and harvesting, Ratoon management ,Sugarcane quality and factors affecting, Disease, insect and pest management , Post harvest handling for marketing; industrial uses of main and by products	
7	Potato :Origin, history, importance, distribution and adaptation, classification, morphology and phenology , Climate, soil, sowing methods ,varieties, Selection of seed and its treatment and fertilizer management , Intercultivation, irrigation, weed control ,Seed plot technique in potato, Harvesting, post harvest care and grading ,quality factors of potato, Scope of true potato seed and its production technology.	6

Lecture schedule - Practical

S.No.	Topic	No. of lectures
1	Study of yield attributing characters of oilseeds, cotton and jute, computation of yield on the basis of yield attributing characters.	1
2	Determination of oil content in oilseeds and computation of oil yield	1
3	Seed treatment of cotton seed with sulphuric acid and cow dung	1
4.	Estimation of protein in oilseed crops	1
5.	Determination of quality of cotton including ginning % and lint index	1
6	Calculation of fertilizer requirements and their application at different growth stages in various crops on the basis of soil test values	1
7	Phenological studies in sugarcane	1
8	Cutting of cane setts, its treatment and method of sowing	1
9	Tying and propping of sugarcane	1
10	Determination of cane maturity and calculation on purity, recovery and sucrose content in juice	1
11	Calculation of seed rate and fertilizer requirement of sugarcane	1
12	Working out cost of cultivation of sugarcane crop	1
13.	Preparation of blue print of sugarcane and potato	1
14.	Phenological studies in potato	1
15.	Selection of potato seed, its treatment and method of sowing	1
16.	Calculation of seed rate and fertilizer requirement for potato	1

Suggested Readings:

- Das, N.R. 2007. Introduction to crops of India. Scientific Publisher, Jodhpur.
- H.C. Srivastava, S. Bhaskaran, B. Vatsyas and K.K.G. MENon, 1985. Oilseed Production : Constraints and Opportunities, Oxford & IBH Company, New Delhi.
- Research and Development Strategies for Oilseed Production in India, 1979. Proceedings of National Symposium, 7-9 Nov. 1979, ICAR Publication, New Delhi.
- P.S. Reddy, 1988. Groundnut, ICAR, New Delhi.
- Chhidda Singh, Prem Singh and Rajbir Singh, 2003. Modern Techniques of Raising Field Crops. Oxford & IBH Publishing Co., New Delhi.
- B.C. Biswas, S. Maheshwari, C. Singh and D.S. Yadav 1984. Cotton, Published by Fertilizer Association of India, New Delhi.
- S.S. Singh, 1988. Crop Management under Irrigated and Rainfed Conditions, Kalyani Publishers, New Delhi.
- P.S. Rathore 2000. Techniques and Management of Field Crop Production. . Agrobios (India) Jodhpur
- Rajendra Prasad, 2002. Text book of field crops production ICAR Pub.
- S.C. Verma and M.P. Singh, 1987. Agronomy of New Plant Types, Text Book Agency, Varanasi.
- P.S. Bhatnagar and S.P. Tiwari, 1990. Technology for increasing soybean production in India, NRCS, Technical Bulletin (ICAR), National Research Centre for Soybean, Indore.
- S.S.Srivastava, D.P.Johari and S.S. Gill. 1988. Manual of Sugarcane Production in India. ICAR Publication, New Delhi.
- J.S.Grewal, R.C.Sharma, S.S.Saini. 1991. Agro-techniques for Intensive Potato Cultivation in India, ICAR Publication, New Delhi.
- J.S.Grewal & V.P.Jaiswal. 1990. Agronomical studies in potato under all India Coordinated Potato Improvement Project, CPRI Pub.Shimla.
- R.L.Yadav. Agronomy of Sugarcane – Principles and Practices.
- B. Sundara 1998. Sugarcane cultivation. Vikas Publishing House Pvt. Ltd.

Ph. D. Programme

AGRON 611

Advances in Crop Growth and Productivity

3(2+1)

Objective

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory:

Physiological limitations to crop yield- leaf area , photosynthesis, dry matter distribution; Solar radiation-concept, agro- techniques for harvesting solar radiation for crop yield ; Cardinal points of vital activities-Schimper`s optima, Hopkin`s Bioclimatic law ; Physiology of germination and seedling emergence - series/steps of germination; Concept of growth analysis- merits and de-merits , LAI, CGR, RGR, NAR, LAR, LAD ; Disadvantages of using leaf area as a basis of growth expression ; Types of growth curves-sigmoid, linear, parabolic and asymptotic ; Principles involved in mixed/inter cropping systems and related terminology, advantages and limitations; Heat unit concept of crop maturity- remainder index, degree days, physiological index and interrelationship; Concept of plant ideotype; Regulation of growth and development of field crops; Bioenergetics of metabolic process.

Practical :

Field measurement of root-shoot relationship in crops at different growth stages; Estimation of growth evaluating parameters like RGR, NAR, CGR, HI, LAI etc at different stages of crop growth, their correlation with final crop yield and interpretation thereof; Construction of crop growth curves on the basis of actual field data; Studying plant competition in intercropping system and calculations of LER, ; Theoretical computation of maximum crop productivity based on radiation receipt in the state; Correlation of crop growth with environmental parameters like temperature , sunshine, relative humidity and its interpretation; Calculation of heat unit requirement of important crops under various agro climatic conditions ; Analysis of productivity trends of important crops both under irrigated and dryland conditions on national and state level.

Lecturer schedule – Theory

S.No.	Topic	No. of lectures
1	Physiological limitations to crop yield- leaf area, photosynthesis, dry matter distribution	2
2	Solar radiation- concepts, agro techniques for harvesting solar radiation for higher crop yield	2
3	Cardinal points of vital activity : Concepts -Schimper`s optima , Cardinal points for temperature for wheat and rice	3
4	Hopkin`s bioclimatic laws	1
5	Physiology of germination and seedling emergence –series/ steps of germination	2
6	Vegetative and reproductive growth- differences	1
7	Growth analysis : Concepts, CGR, RGR, LAR, NAR , LAI, LAD	3
8	Limitations and merits of growth analysis, disadvantages of using leaf area as a basis of growth expression	2
9	Growth curves : Sigmoidal, linear, parabolic and asymptotic	2
10	Principles involved in inter and mixed cropping systems: Concept and differentiation of inter and mixed cropping, related terminology, advantages and limitations of mixed and intercropping	2
11	Criteria in assessing the yield advantages- LER, IER; Competition functions- relative crowding coefficient, aggressivity	2
12	Biological basis for yield advantages- resource use, light	1
13	Heat unit concept of crop maturity : Concept and types of heat units i.e. remainder index, degree days, physiological index and interrelationship	2
14	Concept of plant ideotypes and characteristics of ideotype for dryland area	1
15	Characteristics of ideotype of wheat, pearl millet and chickpea for unirrigated conditions	2
16	Chemical regulation of growth and development in field crops: Concept and types of growth hormones /PGRs	1
17	Application of PGRs in agriculture	1

18	Bioenergetics of metabolic processes-requirement of bioenergetic system, phases of catabolism of food stuffs.	2
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Lecture schedule -Practical

S.No.	Topic	No. of lectures
1	Field measurement of root-shoot relationship in crops at different growth stages.	2
2	Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc, at different stages of crop growth	2
3	Computation of harvest index of various crops	2
4.	Assessment of crop yield on the basis of growth analysis	1
5.	Construction of crop growth curves based on growth analysis data	2
6	Study of plant competition relations in intercropping systems.	1
7	Computation of competition functions viz., LER, aggressivity, competition index etc in intercropping	2
8	Theoretical computation of maximum crop yield on the basis of radiation receipt in the state	1
9	Computation of heat unit and remainder index for various crops	1
10	Analysis of productivity trend in unirrigated areas	1
11	Analysis of productivity trend in irrigated areas	1

Suggested Readings:

- D.J. Watson. 1952. The physiological basis of variation in yield. Advances in Agronomy Vol.4 American Society of Agronomy. Academic Press . Inc. Publishers, New York USA.
- R.W. Willey and S.B. Heath. 1969. Quantitative relationship between plant population and crop yield . Advances in Agronomy Vol.4 American Society of Agronomy. Academic Press . Inc. Publishers, New York USA
- L.T. Evans. 1975. Crop Physiology, Cambridge University Press, London, U.K.
- K.H.W. Klages 1968. Ecological crops geography. The Macmillan Co. New York, USA.
- C.P. Wilsie. 1962. Crop Adaptation and Distribution, W.H. Freeman and Company, San Francisco and London.
- U.S.Gupta. 1979. Physiological Aspects of Dryland Farming (Ed) Oxford and IBH Publishing Co., New-Delhi.
- Scott Russel . 1982. Plant Root Systems, Mc GrawHill Book Company, England.
- U.S. Gupta, 1988. Progress in Crop Physiology. Oxford and IBH Publishing Co., New-Delhi.
- U.S. Gupta, (Ed.) 1995. Production and Improvement of Crops for Drylands. Oxford & IBH, New Delhi
- R.W. Willey. 1979. Intercropping –its importance and research needs Part-I . Field Crop Abstract, CAB, Publication , England, 32-1-9
- Z. Sastak, J. Catsky, and P.G. Jarwis. 1971. Plant photosynthetic Production, Manual of Methods, W. Junk, N. V. Publication.
- S.C.Verma and M.P.Singh. 1987. Agronomy of New Plant Types. Tara Book Company, Varanasi.
- R.M. Delvin and F.H. Witham. 1986. Plant Physiology . CBS Publishers and Distributors, New-Delhi.
- G.Singh, J.S. Kolar and H.S. Sekhon 2002. Recent advances in Agronomy. Indian Society of Agronomy, IARI, New-Delhi.
- P.J. Redford . 1967. Growth Analysis Formulae : Their Use and Abuse, Crop Science 7:171-175.
- A.L. Lehninger. 2006 . Biochemistry . Kalyani Publishers New -Delhi.
- B.N.Chatterjee and B.K. Mandal 1992. Present Trends in Research on Intercropping . *Indian J. Agric. Sci.* 62: 507-518.
- R.L.Yadav, Punjab Singh , R. Prasad and IPS Ahlawat 1998. Fifty Years of Agronomy Research in India ,Indian Society of Agronomy IARI , New-Delhi.

AGRON 612**Advances in Weed Management****3(3+0)****Objective**

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

Weed crop competition in different cropping situations, changes in weed flora, various causes and effects. Absorption, translocation and action of herbicides in plants. Fate of herbicides in plants and soils and factors affecting them, selectivity of herbicides and factors affecting herbicide and environment interaction, residue management of herbicides, adjuvants, advances in herbicide application techniques, herbicide resistance and their remedial measures; Compatibility of herbicides with other pesticides, synergism and antagonism in herbicides, development of transgenic herbicide resistant crops, relationship of herbicides with tillage, fertilizer and irrigation, bio-herbicide approach in weed management.

Lecture schedule – Theory

S.No.	Topic	No. of lectures
1	Weed crop competition in different cropping situations	2
2	Changes in weed flora, various causes and effects	2
3	Absorption, translocation and action of herbicides in plants	
	i. Mechanism of absorption and its kinds	2
	ii. Mechanism of translocation through phloem and xylem	2
	iii. Factors affecting absorption and translocation	2
	iv. Action of herbicides on physiological processes	3
4	Fate of herbicides in plants and soil and factors affecting them	
	i. Transformation of herbicides in plants	3
	ii. Transfer and decomposition of herbicides in soil and factors affecting	3
	iii. Minimizing herbicide persistence in soils	2
5	Physiological and biochemical aspects of selectivity of herbicides and factors affecting these	3
6	Herbicide and environment interaction	2
7	Residue management of herbicides	
	i. Estimation of herbicide residues	3
	ii. Factors affecting herbicide residues on succeeding crops	3
8	Adjuvants – their types and significance in herbicide application	2
9	Advances in herbicide application techniques	2
10	Herbicide resistance and remedial measures	2
11	Compatibility of herbicides with other pesticides	2
12	Synergism and antagonism in herbicides	2
13	Development of transgenic herbicide resistant crops	2
14	Relationship of herbicides with tillage, fertilizer and irrigation	3
15	Bio-herbicide approach in weed management	1

Suggested Readings

- Gupta O.P.2000. Modern Weed Management, Agrobios Publishers.
 Gupta O.P.2007. Weed Management, Principles and Practices, Agrobios
 Rao V.S. 2007. Principles of Weed Science, Oxford & IBH
 Zimdahl RL. 1999. Fundamentals of Weed Sciences 2nd Ed. Academic Press.
 Devine, Duke and Fedtke. 1988. Physiology of Herbicide action
 U.S.Walia, 1990. Weed management, Kalyani Publishers, New Delhi.
 Saraswat VN, Bhan VM & Yaduraju NT, 2003. Weed Management, ICAR
 Streibig JC and Kudsk P. 1993. Herbicide Bioassays, CRC Press Inc.
 Naylor REL. 2002. Weed Management Blackwell Publishing Co.

AGRON 621**Irrigation Management****3(2+1)****Objective**

To teach students about optimization of irrigation in different crops under variable agroclimatic conditions.

Theory

Water resources of India, irrigation projects, irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need, water deficits and crop growth. Soil plant water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity. Infiltration, water movement under saturated and unsaturated conditions, management practices for improving water use efficiency of crops. Application of irrigation water, conveyance and distribution system, irrigation efficiency, agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Strategies of using limited water supply, factors affecting ET, control of ET by mulching and use of antitranspirants. Fertilizer use in relation to irrigation, optimizing the use of given irrigation supplies. Land suitability for irrigation, land irrigability classification, integrated water management in command areas, institution of water management in commands, Farmer's participation in command areas, irrigation legislation.

Practical :

Determination of water infiltration characteristics and water holding capacity of soil profiles. Moisture extraction pattern of crops. Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity. Use of sensors in irrigation scheduling. Determination of uniformity coefficients for sprinkler irrigation system. Evaluation of different methods of irrigation. Agronomic evaluation of irrigation projects, case studies.

Lecture schedule - Theory

S.No.	Topic	No. of lectures
1	Water resources of India	1
2	Irrigation projects- major, medium and minor	2
3	Irrigation needs and factors affecting -atmospheric, soil, agronomic, plant and water factors	2
4	Water deficits and crop growth	2
5	Soil- plant - water relationships	2
6	Transpiration, evapotranspiration and significance of transpiration	1
7	Energy utilization in transpiration, physiological processes and crop productivity	2
8	Infiltration characteristics of soil	1
9	Water movement under saturated and unsaturated conditions	2
10	Management practices for improving water use efficiency of crops	2
11	Application of irrigation water –conveyance and distribution system, irrigation efficiency	2
12	Agronomic consideration in the design and operation of irrigation projects.	2
13	Characteristics of irrigation and farming systems affecting irrigation management .	2
14	Strategies of using limited water supply; factors affecting ET and control of ET by mulching and use of anti-transpirants	2
15	Fertilizer use in relation to irrigation and optimizing the use of given irrigation supplies	2
16	Land suitability for irrigation and land irrigability classification	2
17	Integrated water management in command areas, institutions of water management in commands	2
18	Farmers participation in command areas, irrigation legislation	2

Lecture schedule - Practical

S.No.	Topic	No. of lectures
1	Measurement of infiltration rates in various types of soils	2
2	Determination of water holding capacity of soil profiles	2
3	Moisture extraction pattern of major crops	2
4.	Estimation and measurement of crop water requirements ETo, ETc, kc etc.	2
5.	Use of sensors in irrigation scheduling	2

6	Determination of uniformity coefficients for sprinkler irrigation system	2
7	Evaluation of different methods of irrigation	2
8	Agronomic evaluation of irrigation project, a case study	2

Suggested Readings:

- FAO. 1984. *Irrigation Practice and Water Management*. Oxford & IBH.
Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
Mishra RR & Ahmad M. 1987. *Manual on Irrigation Agronomy*. Oxford & IBH.
Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
Majumdar, D.K. 2004. *Irrigation Water Management: Principles and Practice*. Prentice Hall of India, New Delhi

AGRON 622

Stress Crop Production

3(2+1)

Objective

To study various types of stresses in crop production and strategies to overcome them.

Theory

Stress and strain terminology; nature of stress injury and resistance; causes of stress; low temperature; viz., chilling and freezing injury and resistance; high temperature or heat stress injury and resistance; water stress viz; water deficit, excess water or flooding stresses injury and resistance; salt stress and its effect on plant growth, stress injury and resistance; practical ways of overcoming various stresses through soil and crop manipulations; environmental pollution viz. air, soil and water and their effect on crop growth and quality.

Practical:

Determination of electrical conductivity of plant cell sap; determination of osmotic potential and tissue water potential; measurement of transpiration rate; measurement of stomatal frequency; growing of plants in sand culture and in artificially salinized soil in pots for biochemical and physiological studies; effect of drought and salt stress on plant growth; effect of osmotic and ionic stress on seed germination and seedling growth, fertilizer management under water and salt stress conditions; study of low temperature injury under field conditions.

Lecture Schedule – Theory

S. No.	Topic	No. of lectures
1	Stress and strain terminology	2
2	Nature of stress injury and resistance	1
3	Causes of stress	1
4	Low temperature stress - freezing injury and resistance in plants, measurement of freezing tolerance ,	2
	Chilling injury and resistance in plants	2
	Practical ways to overcome the effect of low temperature stress through soil and crop manipulations	1
5	High temperature or heat stress: Meaning of heat stress, heat injury and resistance in plants	2
	Practical ways to overcome the effect of heat stress through soil and crop manipulations	2
6	Water deficit stress: Meaning of plant water deficit stress and its effect on growth and development	2
	Water deficit injury and resistance	2
	Practical ways to overcome effect of water deficit stress through soil and crop manipulations	1
7	Excess water or flooding stress Meaning of excess water stress, its kinds and effects on crop plants	1
	Excess water stress injury and resistance	1

	Practical ways to overcome excess water stress through soil and crop manipulations	2
8	Salt stress:	
	Meaning of salt stress and its effect on crop growth	2
	Salt stress injury and resistance in plants	2
	Practical ways to overcome the effect of salt stress through soil and crop manipulations	2
	Environmental pollution viz., air, soil and water and their effect on crop growth and quality	2
	Ways and means to prevent environmental pollution	2

Lecture Schedule – Practical

S.No.	Topic	No. of lectures
1	Determination of electrical conductivity of plant cell sap	1
2	Determination of osmotic potential and tissue water potential	2
3	Measurement of transpiration rate	1
4.	Measurement of stomatal frequency	1
5.	Growing of plants in sand culture and under saline stress (artificial salinized soil in pot) for biochemical and physiological studies	3
6	Studies on effect of drought and salt stress on plant growth	2
7	Studies on effect of osmotic and ionic stress on seed germination and seedling growth	2
8	Fertilizer management under water and salt stress conditions	2
9	Study of low temperature injury under field conditions	2

Suggested Readings:

- Baker FWG.1989. *Drought Resistance in Cereals*. Oxon, UK.
Gupta U.S. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.
Kramer PJ.1983. *Water Relations of Plants*. Academic Press.
Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
Mavi HS.1994. *Introduction to Agro-meteorology*. Oxford & IBH.
Nilsen ET & Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
Singh K. 2000. *Plant Productivity under Environmental Stress*. Agrobios.
Somani LL & Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.
Virmani SM, Katyal JC, Eswaran H & Abrol IP.1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

List of Agronomy Journals

• Advances in Agronomy
• Agriculture, Ecosystems and Environment
• Agricultural Systems
• Agricultural Water Management
• Agronomy Journal
• Annual Review of Plant Physiology
• Applied Ecology and Environment Research
• Australian Journal of Agricultural Research
• Australian Journal of Experimental Agriculture
• Crop Protection
• Environment and Ecology
• European Journal of Agronomy
• Fertilizer Research
• Field Crops Research
• Indian Journal of Agricultural Sciences
• Indian Journal of Agronomy
• Indian Journal of Ecology
• Indian Journal of Weed Science
• Irrigation Science
• Japanese Journal of Crop Science

• Journal of Agronomy
• Journal of Applied Ecology
• Journal of Experimental Botany
• Journal of Farming Systems Research
• Journal of Range Management
• Journal of Agricultural Science Cambridge
• Journal of Sustainable Agriculture
• Netherlands Journal of Agricultural Sciences
• Nutrient Cycling in Agroecosystems
• Pesticide Biochemistry and Physiology
• Plant and Soil
• Plant Production Science
• Soil and Tillage Research
• Swedish Journal of Agricultural Research
• Tropical Agriculture
• Weed Research

Suggested Broad Topics for Master's and Doctoral Research

- Crop diversification under different agricultural situations
- Development of farming systems for marginal, small and other farmers
- Agricultural information at door step/click of mouse
- Farm-specific nutrient management
- Weed management in different cropping/farming systems
- Nutrient studies in different cropping/farming systems
- Biodiversity of farming systems for conservation
- Organic farming systems for different regions
- Modelling for different crop situations
- Conservation agriculture for yield sustainability
- Role of edaphic factors on weeds proliferation and management
- Implications of global warming on weed growth and herbicide behaviour
- Ecological implications of using thresholds for weed management
- Effect of cultivation practices and herbicides on weed flora shift
- GM crops and weed management strategies
- Weed management under reduced moisture regime in major summer/*kharif* crops
- Avoidance of herbicide resistance using IWM

AGRICULTURAL ECONOMICS

M.Sc. (Ag.) Programme

I Semester

Course No.	Course title	Credit hours
AGECON 511*	Micro Economic Theory and Application	3(3+0)
AGECON 512*	Macro-Economics and policy	3(3+0)
AGECON 513*	Agricultural Production Economics	3(2+1)

II Semester

AGECON 521*	Agricultural Marketing and Price Analysis	3(2+1)
AGECON 522#	Research Methodology for Social Sciences	3(2+1)
AGECON 523#	Econometrics	3(2+1)
AGECON 524@	International Economics	3(2+1)

III Semester, M.Sc.(Ag)

AGECON 531@	Agricultural Finance and Project Management	3(2+1)
AGECON 532@	Agricultural Development and Policies	3(3+0)

IV Semester

AGECON 541#	Master's Seminar	1(0+1)
AGECON 542#	Comprehensive	2(0+2)
AGECON 543#	Master's Research	15

Ph.D. Programme

I Semester

AGECON 611*	Advanced Micro- Economic Analysis	3(3+0)
AGECON 612*	Advanced Macro Economic Analysis	3(3+0)

II Semester

AGECON 621#	Advanced Agricultural Marketing and Price Analysis	3(2+1)
AGECON 622#	Advanced Production Economics	3(2+1)

III Semester

AGECON 641	Seminar I& II	2(0+2)
AGECON 642	Preliminary	4(0+4)
AGECON 643	Research	40

* Core courses

Compulsory courses

@ Optional courses

Minor courses for M.Sc. and Ph.D. for the students of related disciplines as under :

Course No.	Course title	Credit hours
AGECON 513	Agricultural Production Economics	3(2+1)
AGECON 511	Micro Economic Theory and Application	3(3+0)
AGECON 521	Agricultural Marketing and Price Analysis	3(2+1)
AGECON 531	Agricultural Finance and Project Management	3(2+1)

Minor and supporting/related courses for students of M.Sc.(Ag.) and Ph.D. (Agricultural Economics)

M.Sc.(Ag.)

Supporting courses

i.	STAT 511	Statistical methods	3(2+1)
ii.	EXT 512	Development Communication and Information Management	3(2+1)
iii.	STAT 531	Time Series Analysis	3(2+1)
iv.	EXT 532	Visual Communication	3(2+1)

Ph.D.

Supporting /related courses

i.	EXT 523	Human Resource Development	3(2+1)
ii.	EXT 513	Diffusion and Adoption of Innovation	3(2+1)
iii.	EXT 532	Visual Communication	3(2+1)

Minor courses

i.	STAT 522	Applied Regression Analysis	3(2+1)
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Note: If required an another course (related / minor) running in a particular semester may also be offered.

AG ECON 511 Micro Economic Theory and Applications**3(3+0)****Objective**

This course is intended to provide an overview of microeconomic theory and its applications. The course starts with the theory of consumer behaviour consisting of consumer's utility maximization problem and demand theory. It intends to provide fundamental concepts and models in the theory of production and costs and sets out to provide a basic understanding of price and / or output determination under different types of market structures including factor markets. This course will also expose the students to the theory of general equilibrium and welfare economics.

Theory

Theory of Consumer behaviour - Cardinal Utility Approach – Ordinal Utility Approach – Income effect and substitution effect – Applications of Indifference curve approach - Revealed Preference Hypothesis – Consumer surplus - Derivation of Demand curve – Elasticity of demand, Theory of Production - Production functions – Returns to scale and economies of scale – Technical progress – Theory of Costs – Cost curves– Profit maximization and cost minimization – Derivation of supply curve – Law of Supply – Producers' surplus, Market Equilibrium - Behavior of Firms in Competitive Markets – Perfect Competition- Effect of Taxation and Subsidies on market equilibrium - Monopoly- Monopolistic – Oligopoly, General Equilibrium Theory - Welfare Economics - Pareto Optimality – Social welfare criteria - Social Welfare functions.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Theory of Consumer behaviour	2
2.	Cardinal Utility Approach	2
3.	Ordinal Utility Approach	2
4.	Income Effect	2
5.	Substitution effect	2
6.	Application and indifference curve	2
7.	Revealed preference hypothesis	2
8.	Consumer surplus	1
9.	Derivation of demand curve	1
10.	Elasticity of demand	1
11.	Production function	1
12.	Return to scale and economic s of scale	1
13.	Technical progress	1
14.	Theory of cost	1
15.	Cost curve	2
16.	Profit maximization	2
17.	Cost minimization	1
18.	Derivation of supply curve	1
19.	Law of supply	1
20.	. Production surplus	1
21.	Market equilibrium	1
22.	Behaviour of the firms in competition markets	1
23.	Perfect competition	1
24.	. Effect of taxation and subsidies	1
25.	Monopoly	2
26.	Monopolistic competition	2
27.	.Oligopoly	2
28.	General equilibrium	2
29.	Welfare economics	2
30.	Pareto optionality	2
31.	Social Welfare criteria	2
32.	Social welfare functions	2
	Total	48

Suggested Readings

David M Kreps 1990. *A Course in Microeconomic Theory* . Princeton University Press.

Dewitt K.K. 2002. *Modern Economic Theory* . Sultan Chand & Co.

Henderson J.M & Quandt R.E. 2000. *Microeconomic Theory: A Mathematical Approach* . McGraw-Hill.

Jhingan, M.L. 2004. *Micro Economic Theory*. Vikash Publishing House Pvt. Ltd. New Delhi.
 Koutsoyiannis A. 2003. *Modern Microeconomics*. The Macmillan Press.
 Silberberg E & Suen W. 2001. *The Structure of Economics – A Mathematical Analysis*. McGraw-Hill.
 Varian Hal R. 1999. *Intermediate Microeconomics*. Affiliated East-West Press.

AG ECON 512

Macro Economics and Policy

3(3+0)

Objective

Macro economics and Policy course is intended to expose the students to macroeconomic concepts and theory, the application of the macro economic theory, and implication of the macroeconomic policies.

Theory

Nature and Scope of Macro Economics - Methodology and Keynesian Concepts National Income - Concepts and measurement- Classical theory of Employment and Say's Law-Modern theory of Employment and Effective Demand, Consumption function- Investment and savings - Concept of Multiplier and Accelerator - Output and Employment - Rate of interest - Classical, Neo classical and Keynesian version- Classical theory Vs Keynesian theory - Unemployment and Full employment, Money and classical theories of Money and Price - Keynesian theory of money and Friedman Restatement theory of money - Supply of Money - Demand for Money -Inflation: Nature, Effects and control, IS & LM frame work - General Equilibrium of product and money markets -Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy - Central banking, Business cycles - Balance of Payment - Foreign Exchange Rate determination.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Nature and Scope of Macro-economics-----	2
2.	Methodology and Keynesian concept -----	2
3.	National Income- concepts measurement-----	2
4.	Classical theory of Employment and Shy's law-----	2
5.	Modern theory of employment and effective demand -----	2
6.	Consumption function – Instrument and savings-----	2
7.	Concept of Multiplier and Accelerator-----	3
8.	Output and employment-----	3
9.	Rate of Interest – classical, Nea – classical and Keynesian variation	3
10.	Classical theory Vs Keynesian theory-----	3
11.	Unemployment and full employment -----	2
12.	Money and classical theory of money and prices-----	3
13.	Keynesian theory of money and Friedman Restatement the of money-----	3
14.	Supply of Money-Demand of Money -----	2
15.	Inflatiion: Nature, Effects and Central-----	2
16.	IS & LM frame work-----	2
17.	General Equilibrium of product and money Markets-----	2
18.	Monetary policy –Fiscal policy – effectiveness of Monetary and fiscal policy-----	3
19.	Central Banking	1
20.	Business cycles- Balance of payment	2
21.	Foreign Exchange Rate determination	2
	Total	48

Suggested Readings

Ahuja H.L. 2007. *Macroeconomics: Theory and Policy*. S. Chand & Co.
 Eugene A Diulio 2006. *Macroeconomics*. 4 Ed. Schaums' Outlines. th
 Gardner Ackely 1987. *Macro Economic: Theory and Policy*. Collier Macmillan.
 Dornbusch. 2006. *Macroeconomics*. McGraw Hill Publication.

AGECON 513

Agricultural Production Economics

3(2+1)

Objective

To expose the students to the concept, significance and uses of agricultural production economics.

Theory

Nature, scope and significance of agricultural production economics- Agricultural Production processes,

character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions, Factors of production, classification, interdependence, and factor substitution -Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination. Cost functions and cost curves, components, and cost minimization - Duality theory – cost and production functions and its applications - Derivation of firm’s input demand and output supply functions –Economies and diseconomies of scale, Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk.

Practical

Different forms of production functions - specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap - incorporation of technology in production functions- measuring returns to scale.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1	Nature, scope and significance of agriculture production economics	1
2	Agricultural production processes, character and dimensions-Spatial and temporal	2
3	Assumptions of production functions	1
4	Properties, limitations, specification,, estimation and interpretation of commonly used production functions.	5
5	Factors of production, classification, interdependence, and factor substitution	2
6	Determination of optimal levels of production and factor application	2
7	Optimal factor combination and least cost combination of production.	2
8	Theory of product choice; selection of optimal product combination	2
9	Cost functions and cost curves, components of cost	2
10	Cost minimization	2
11	Duality theory-cost and production functions and its applications –Derivation of firm’s input demand and output supply functions	2
12	Economies and diseconomies of scale	1
13	Technology in agricultural production, nature and effects and measurement	2
14	Measuring efficiency in agricultural production; technical allocative and economic efficiencies	2
15	Yield gap analysis-concepts-types and measurement	2
16	Nature and sources of risk	2
	Total	32

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	Different forms of production functions-specification, estimation and interpretation of production functions	5
2	Measuring returns to scale	1
3	Factor shares	1
4	Elasticity of production	1
5	Physical optima- economic optima	2
6	Least cost combination	1
7	Optimal product choice –cost function estimation and interpretation	2
8	Estimation of yield gap	2
9	Incorporation of technology in production functions	1
	Total	16

Suggested Readings

Beattie B.R & Taylor C.R. 1985. *The Economics of Production* . John Wiley & Sons.
Doll J.P & Frank O. 1978. *Production Economics - Theory and Applications* . John Wiley & Sons.
Gardner B.L & Rausser G.C. 2001. *Handbook of Agricultural Economics Vol. I. Agricultural Production* . Elsevier.

Heady E.O. *Economics of Agricultural Production and Resource Use* .Prentice-Hall.
Sankayan P.L. 1983. *Introduction to Farm Management* . Tata Mc Graw Hill.

AG ECON 521 Agricultural Marketing and Price Analysis

3(2+1)

Objective

To impart adequate knowledge and analytical skills in the field of agricultural marketing issues, and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities.

Theory

Review of Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration – Integration over space, time and form-Vertical co-ordination, Marketing Co-operatives – APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies - Market infrastructure needs, performance and Government role, Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service - electronic auctions (e-bay), e-Chaupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) – Market extension, Spatial and temporal price relationship – price forecasting – time series analysis – time series models. Price policy and economic development – non-price instruments.

Theory of storage - Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets – Price discovery - Hedging and Basis - Fundamental analysis - Technical Analysis - Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios. Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Chain Analysis - quantitative estimation of supply chain efficiency - Market Intelligence – Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Agricultural Marketing; Review of Concepts in Agricultural Marketing	1
2	Characteristics of Agricultural products and Production	1
3	Problems in Agricultural Marketing from Demand and Supply and Institutions Sides	2
4	Market Intermediaries and their role-Need for regulation in present context	1
5	Marketable and Marketed Surplus and their estimation	1
6	Marketing Efficiency and Market Integration types of Market Integration. Integration over space, time and form. Co-Integration	2
7	Marketing Co-operatives-APMC Regulated Markets	2
8	Direct marketing, Contract farming and Retailing	2
9	Supply Chain Management –State trading	2
10	Warehousing and other Government agencies	2
11	Govt. agencies their Performance and Strategies	2
12	Market infrastructure needs, performance and Govt. role	1
13	Role of Information Technology and tele-communication in marketing of agricultural Commodities	1
14	Market research and Market information service electronic-auctions (e-bay). e-chaupals	1
15	Agriculture market and Domestic and Export market Intelligence-Cell (DEMIC), Market extension	1
16	Spatial and temporal price relationship price forecasting	2
17	Time series analysis-time series models price policy economic development	2
18	Storage –Introduction to Commodities markets and Future trading	1

19	Basics of Commodity futures –Operation Mechanism of Commodity markets	1
20	Price discovery –Hedging and Basis-Fundamental analysis-Technical Analysis	2
21	Role of Government in Promoting Commodity-trading and regulatory measures	2
	Total	32

Lecture schedule: Practical

S. No.	Title	No. of lectures
1	Supply and demand-elasticity in relation to problems in agricultural marketing	1
2	Price Spread and marketing efficiency analysis	2
3	Performance analysis of Regulated market and marketing societies	2
4	Analysis on Contract farming	1
5	Supply Chain management of different agricultural Commodities-milk and poultry products. Chain Analysis –Quantitative estimation of supply Chain efficiency	6
6	Market Intelligence-Characters , Accessibility and Availability Price forecasting , Online searches for market information sources and Interpretation of market intelligence reports	4
	Total	16

Suggested Readings

- Purecell W.D & Koontz S.R. 1999. *Agricultural Futures and Options: Principles and Strategies* . 2nd Ed. Prentice-Hall.
- Rhodes V.J. 1978. *The Agricultural Marketing System* . Grid Publ., Ohio.
- Shepherd S.G & Gene A.F. 1982. *Marketing Farm Products* . Iowa State Univ. Press.
- Singhal A.K. 1986. *Agricultural Marketing in India* . Annual Publ., New Delhi.

AGECON 522

Research Methodology for Social Sciences

3(2+1)

Objective

To expose the students to research methodology used in social sciences. The focus will be on providing knowledge related to research process, data collection and data analysis etc.

Theory

Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process, Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing, Sampling theory and sampling design – sampling error - methods of sampling – probability and non-probability sampling methods - criteria to choose. Research design and techniques – Types of research design, Hypothesis – meaning - characteristics - types of hypothesis – review of literature – setting of Course Objective and hypotheses - testing of hypothesis, Preparing research report / thesis – Universal procedures for preparation of bibliography – writing of research articles.

Practical

Exercises in problem identification. Project proposals – contents and scope. Formulation of Objective and hypotheses. Assessment of data needs – sources of data – methods of collection of data. Methods of sampling – criteria to choose – discussion on sampling under different situations. Preparation of interview schedule - Field testing. Method of conducting survey. Preparing for data entry into computer. Hypothesis testing – Parametric and Non-Parametric Tests. Exercises on format for Thesis / Report writing. Presentation of the results.

Lecture schedule: Theory

S.No.	Topic	No of lectures
1.	Importance and scope of agricultural economics	1
2.	Type of research – Fundamental Vs Applied	1
3.	Research prioritization	1
4.	Selection of research problem	2
5.	Approaches to research – research process	1
6.	Data collection- assessment of data needs	1

7.	Sources of data collection – discussion of different situations	1
8.	Mailed questionnaire and interview schedule	2
9.	Structured , unstructured, open ended and closed ended question	1
10.	Scaling techniques	2
11.	Preparation of schedules	1
12.	Problems in measurement of variables in agriculture	1
13.	Interviewing techniques and field problem	2
14.	Methods of conducting survey	1
15.	Reconnaissance survey and pretesting	1
16.	Sampling theory and sampling design-sampling error	2
17.	Methods of sampling – probability and non – probability sampling method- criteria to choose	2
18.	Research design and techniques – type of research design	1
19.	Hypothesis – meaning – characteristics and types	1
20.	Review of literature- setting of course objective and hypothesis	1
21.	Testing of hypothesis	1
22.	Preparing research report /thesis	2
23.	Universal procedure for preparation of bibliography	1
24.	Writing of research articles.	2

Lecture schedule: Practical

S.No.	Topic	No of lectures
1.	Exercise in problem identification	1
2.	Project proposals- contents and scope	1
3.	Formulation of objectives and hypothesis	1
4.	Assessment of data needs – sources of data	2
5.	Methods of sampling – criteria to choose	2
6.	Preparation of interview schedule-field testing	2
7.	Method of conducting survey	1
8.	Preparing for data entry in to computer	2
9.	Preparation of hypothesis	1
10.	Exercise on format for thesis / report writing	2
11.	Presentation of the results	1
	Total	16

Suggested Readings

- Black T.R. 1993. *Evaluating Social Science Research - An Introduction* . SAGE Publ.
- Creswell J.W. 1999. *Research Design - Qualitative and Quantitative Approaches*. SAGE Publ.
- Dhondyal S.P. 1997. *Research Methodology in Social Sciences and Essentials of Thesis Writing* . Amman Publ. House, New Delhi.
- Kothari C.R. 2004. *Research Methodology - Methods and Techniques* . Wishwa Prakashan, Chennai.
- Rao K.V. 1993. *Research Methodology in Commerce and Management*. Sterling Publ., New Delhi.
- Singh A.K. 1993. *Tests, Measurements and Research Methods in Behavioural Sciences*. Tata McGraw-Hill.
- Venkatasubramanian V. 1999. *Introduction to Research Methodology in Agricultural and Biological Sciences*. SAGE Publ.

AG ECON 523

Econometrics

3(2+1)

Objective

The Course Objective of the course is to impart knowledge on econometric tools to the students of agricultural economics. Training in econometrics will help the student to analyze the economic problem by applying quantitative techniques

Theory

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics- regression analysis, Basic two variable regression - assumptions estimation and interpretation- approaches to estimation - OLS and their properties -multiple regression estimation and

interpretation, Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches - model misspecification, Use of dummy variables- specification, estimation and interpretation, Simultaneous equation models - identification and approaches to estimation.

Practical

Single equation two variable model specification and estimation - hypothesis testing- transformations of functional forms and OLS application-estimation of multiple regression model - hypothesis testing , testing and correcting specification errors - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation - estimation of regressions with dummy variables - estimation of regression with limited dependent variable - identification of equations in simultaneous equation systems.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Relationship between economic theory , Mathematical economics, Models and Econometrics	2
2.	Methodology of Econometrics	2
3.	Regression analysis	2
4.	Basic two variable regression	2
5.	Assumptions	2
6.	Estimation	2
7.	. Interpretation	1
8.	Violation of assumption	2
9.	Identification	1
10.	Multicollinearity	2
11.	Consequences of Multicollinearity	1
12.	Remedies of Multicollinearity	2
13.	Hetero scadastocity	2
14.	Auto correction	1
15.	Data problems	1
16.	Remedial measures	2
17.	Use of dummy variables	1
18.	Specification	1
19.	Estimation & Interpretation	1
20.	Simultaneous equation models	1
21.	Identification and approaches to estimation	1

Lecture schedule: Practical

S.No.	Topics	No. of lectures
1	Single equation two variable model specification and estimation	2
2	Hypothesis testing	2
3	Transformation of functional forms and OLS application	2
4	Estimation of multiple regression model	2
5	Hypothesis testing	1
6	Testing and correction specification errors	1
7	Testing and managing multicolliverty	1
8	Testing and managing auto correction	1
9	Testing and managing autocorrection	1
10	Estimation of regression with dummy variables	1
11	Estimation of regression with limited dependable linear	1
12	Identification of equation in simultaneous equation system	1
	Total	16

Suggested Readings

Gujarati D.N. 2003. *Basic Econometrics* . McGraw Hill.
 Johnson A.G Jr., Johnson M.B & Buse RC. 1990. *Econometrics - Basic and Applied*.MacMillan.
 Kelejan H.H & Oates WE. 1994. *Introduction to Econometrics Principles and Applications*. Harper and Row Publ.

- Koutsoyianis A. 1997. *Theory of Econometrics* . Barner & Noble.
 Maddala G.S. 1992. *Introduction to Econometrics* . MacMillan.
 Maddala G.S. 1997. *Econometrics*. McGraw Hill.
 Pindyck R.S & Rubinfeld D.L. 1990. *Econometrics Models and Econometric Forecasts* . McGraw Hill.

AGECON 524

International Economics

3(2+1)

Objective

The expected outcome of this course will be creating awareness among the students about the role of International Economics on National welfare.

Theory

Scope and Significance of International Economics - The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy - Possibility of World Trade, Trade gains and Trade Equilibrium, Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case, Heckscher – Ohlin Model - Trade Creation and Trade Diversion – Offer Curve – Export Supply Elasticity and Import Demand Elasticity - Comparative Advantage and Absolute Advantage, Official Exchange Rate and Shadow Exchange Rate - Walra’s Law and Terms of Trade, IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

Practical

National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption- Estimation of Trade Gains- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC- Estimation of Offer Curve Elasticity- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraints on National Welfare- Estimation of trade Equilibrium under Heckscher -Ohlin model.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1	Scope and significance of international economics	1
2	The role of trade	1
3	General equilibrium in a closed economy (Autarky equilibrium)	2
4	Equilibrium in a simple open economy	2
5	Possibility of world trade	1
6	Trade gains and trade equilibrium	2
7	Tariff	2
8	Producer subsidy	1
9	Export subsidy	1
10	Import quota and export voluntary Restraints-The case of small country and large country case	2
11	Heckscher-Ohlin Model	2
12	Trade creation and trade division	1
13	Offer Curve, Export supply elasticity and import demand elasticity	2
14	Comparative advantage and absolute advantage	2
15	Official Exchange Rate and Shadow Exchange Rate	2
16	Walra’s Law and Terms of Trade	2
17	IMF, World Bank, IDA, IFC, ADB	3
18	International trade agreements Uruguay Round-GATT –WTO	3
	Total	32

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	National welfare under Autarky and Free Trade Quilibrium with small and large country	2
2	Estimation of Trade gains	1
3	Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC	4
4	Estimation of offer curve elasticity	2

5	Estimation of effect of tariff, export subsidy, producer subsidy, import quota and export voluntary restraints on national welfare	6
6	Estimation of trade equilibrium under Heckscher-Ohlin model	1
	Total	16

Suggested Readings

Apple Yard D.R & Field A.J Jr. 1995. *International Economics - Trade, Theory and Policy*. Irwin, Chicago.
 Cherunilam F. 1998. *International Economics*. Tata McGraw Hill.
 Krugman P.R & Obstfeld M. 2000. *International Economics – Theory and Policy*. Addison-Wesley.

AGECON 531 Agricultural Finance and Project Management 3(2+1)

Objective

The Course Objective of the course is to impart knowledge on issues related to lending to priority sector credit management and financial risk management. The course would bring in the various appraisal techniques in project - investment of agricultural projects.

Theory

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's. Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals, Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm, Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques – PERT and CPM, Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes - yield loss and weather based insurance and their applications.

Practical

Rural Lending Programmes of Commercial Banks, Lead Bank Scheme- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements, Performance of Micro Financing Institutions - NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques – Undiscounted Measures and their limitations. Project appraisal techniques – Discounted Measures, Network techniques – PERT and CPM for project, management, Case Study Analysis of an Agricultural project, Financial Risk and risk management strategies – crop insurance schemes, Financial instruments and methods – E banking, Kisan Cards and core banking.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1	Role and Importance of Agricultural Finance	1
2	Financial Institutions and Credit flow to rural/priority Sector	1
3	Agricultural lending-Direct and Indirect Financing	1
4	Financing through Co-operatives, NABARD	2
5	Financing through Commercial Banks and RRBs	2
6	District Credit Plan and lending to agriculture/priority Sector	1
7	Micro-Financing and Role of MFI's –NGO's	1
8	Lending to farmers –Concept of 3 C's	1
9	7P's and 3 R's of Credit	2
10	Estimation of Technical feasibility and Economic Viability	2
11	Estimation of repaying capacity of borrowers	2
12	Appraisal of credit proposals	1
13	Preparation of financial Statements-Balance Sheet cash flow Statement and Profit and Loss statement	2
14	Ratio Analysis and Assessing the performance of farm/firm	1

15	Identification, preparation, appraisal, financing and Implementation of projects	2
16	Project Appraisal techniques-Undiscounted measures	2
17	Time value of money-Use of discounted measures-B.C. ratio, NPV and IRR	2
18	Agreements, Supervision, monitoring and evaluation phases in appraising agricultural investment projects-	1
19	Network Techniques- PERT and CPM	2
20	Risks in financing agriculture-Risk management strategies and coping mechanism	1
21	Crop Insurance programmes –review of different crop insurance schemes- yieldloss and weather based insurance and their applications	2
	Total	32

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	Rural Lending Programmes of Commercial Banks	1
2	Lead Bank Scheme, Co-operative Lending Institutions	2
3	Preparation of financial Statements using farm/firm level data	1
4	Farm credit appraisal techniques and farm financial analysis through financial statements	1
5	Performance of Micro-Financing Institutions-NGO's and Self Help Groups	2
6	Project appraisal techniques- Undiscounted Measures and their limitations	2
7	Project appraisal techniques-Discounted Measures, Network Techniques-PERT and CPM for project management	4
8	Case Study Analysis of an Agricultural project, Financial instruments and methods –E-banking, Kisan Credit Cards and Core banking.	3
	Total	16

Suggested Readings

- Dhubashi P.R. 1986. *Policy and Performance - Agricultural and Rural Development in Post Independent India*. Sage Publ.
- Gittinger J.P 1982. *Economic Analysis of Agricultural Projects*. The Johns Hopkins Univ. Press.
- Gupta S.C. 1987. *Development Banking for Rural Development*. Deep & Deep Publ.
- Little I.M.D & Mirlees J.A. 1974. *Project Appraisal and Planning for Developing Countries*. Oxford & IBH Publ.
- Muniraj R. 1987. *Farm Finance for Development*. Oxford & IBH Publication.

AG ECON 532 Agricultural Development and Policies

3(3+0)

Objectives

To provide orientation to the students regarding the concepts and measures of economic development. To provide orientation on theories of economic growth and relevance of theories in developing countries.

Theory

Development Economics – Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development – GNP as a measure of economic growth – New Measures of Welfare. Criteria for under development – Obstacles to economic development – Economic and Non-Economic factors of economic growth, Economic development – meaning, stages of economic development, determinants of economic growth. Theories of economic growth – Ricardian growth model – The Harrod – Domar Model – Marxian model, Schumpeter, Lewis Model. Role of state in economic development – Government measures to promote economic development. Introduction to development planning, Role of agriculture in economic / rural development – theories of agricultural development – Population and food supply - need for sound agricultural policies – resource policies – credit policies – input and product marketing policies – price policies.

Development issues, poverty, inequality, unemployment and environmental degradation – Models of Agricultural Development – Induced Innovation Model - policy options for sustainable agricultural development, Globalization and the relevance of development policy analysis – The dilemma of free trade? – Free trade versus Protectionism- Arguments for protection. Arguments against protection. Role of protection in Developing Countries. WTO – Agreement on Agriculture - Contradictions of free trade - proponents and opponents policies in vulnerable sectors like agriculture – Lessons for developing countries.

Lecture schedule: Theory

S.No.	Topic	No of lectures
1.	Development Economics-Scope and Importance	2
2.	Economic development and economic growth – divergence in the concept and approach	2
3.	Indicators and measurement of economic development GNP as a measure of economic growth –new measures of welfare	2
4.	Criteria for under –development –obstacles to economic development	2
5.	Economic and Non economic factors economic growth	2
6.	Economic development –meaning , state of economic development, determining economic Growth	2
7.	Theories of economic growth – Ricardian growth model The Harrod- Domar model Marxian model Schemputer model Lewis model	3
8.	Role of state in economic development. Govt. measures to promote economic development.	2
9.	Introduction to development planning	2
10.	Role of agriculture in economic /rural development	2
11.	Theories of agricultural development	3
12.	Population and food supply –need for sound agriculture policies	2
13.	Resource policies – credit policies- input and product marketing policies – price policies	3
14.	Development issues, poverty, inequality, unemployment and environmental degradation	3
15.	Models of Agricultural Development – poverty options for sustainable agricultural development	3
16.	Globalization and the relevance of development policy analysis	2
17.	The dilemma of free trade ? Free trade versus protectionism- argument for and Protection	2
18.	Role of protection in developing countries	2
19.	WTO – Agreement on Agriculture – contradiction of free trade	3
20.	Proponents and opponents policies in vulnerable sectors like agriculture- lessons for developing countries	2

Suggested Readings

- Chakaravathi R.M. 1986. *Under Development and Choices in Agriculture* Heritage Publ., New Delhi.
- Diwett K.K. 2002. *Modern Economic Theory*, S. Chand & Co.
- Eicher K.C & Staats J.M. 1998. *International Agricultural Development*. Johns Hopkins Univ. Press.
- Frank E. 1992. *Agricultural Policies in Developing Countries*. Cambridge Univ. Press.
- Ghatak S & Ingersent K. 1984. *Agriculture and Economic Development*. Select Book Service Syndicate, New Delhi.
- Jhingan M.L. 1998. *The Economics of Development and Planning*. Vrinda Publ.
- Jules P.N. 1995. *Regenerating Agriculture – Policies and Practice for Sustainability and Self Reliance* . Vikas Publ. House.
- Naqvi S.N.H. 2002. *Development Economics – Nature and Significance*. Sage Publ.

Ph. D Programme**AGECON 611****Advanced Micro Economic Analysis****3(3+0)****Objectives**

The Course Objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization,

expenditure minimization, constrained profit maximization, and cost and expenditure minimization.

Theory

Theory of consumer behaviour – Duality in consumer theory – expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers' Welfare – Consumer's Surplus, Compensating Variation and Equivalent Variation - Dynamic versions of demand functions – Integrability of demand functions. Demand Models – Linear Expenditure System, Perfect competition – Monopoly, monopolistic competition and oligopoly. Oligopoly models – collusive and non-collusive models of oligopoly - Cournot model, Chamberlin model. General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Market failure - Incomplete markets - Asymmetric information – Principal- Agent problem, adverse selection and moral hazard. Externalities – Network externalities - Public goods – Optimal provision of public goods. Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics, Pareto conditions of maximum welfare – Criteria for social welfare - Social Welfare functions, Social versus Private costs and benefits.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Theory of consumer behaviour	2
2.	Duality in consumer theory	2
3.	Expenditure function and indirect utility function	2
4.	Measurement of income effect and substitution effect	2
5.	Measurement of changes in consumers welfare	2
6.	Consumer's surplus	2
7.	Compensating variation and equivalent variation	2
8.	Dynamic variation of demand function – Integrability of demand function	2
9.	Demand Models – Linear Expenditure system	2
10.	Perfect competition- Monopoly, Monopolistic competition and Oligopoly.	3
11.	Oligopoly models collective and non-collective models of oligopoly	3
12.	Cournot model and Chamberlin model	3
13.	General equilibrium theory – conceptual overview	2
14.	General equilibrium condition with production and consumption	2
15.	Existence, Uniqueness and stability of general competitive equilibrium	3
16.	Market failure – Incomplete markets – Asymmetric information	2
17.	Principal – Agent Problem, adverse selection and moral hazard	2
18.	Externalities – Network externalities – public goods optional provision of public goods,	3
19.	Welfare Economics – concepts, problems, approaches and limitations	2
20.	Pareto condition of Maximum welfare	2
21.	Criteria for social welfare- Social welfare function	2
22.	Social versus private costs and benefits	1
	Total	48

Suggested Readings

Chiang A.C. 1981. *Fundamental Methods of Mathematical Economics*. McGraw-Hill.
Henderson J.M & Quandt R.E. *Microeconomic Theory: A Mathematical Approach*. McGraw-Hill.
Koutsoyiannis A. 2003. *Modern Microeconomics*. The Macmillan Press.
Kreps D.M. 1990. *A Course in Microeconomic Theory*. Princeton Univ. Press.
Silberberg E & Suen W. 2001. *The Structure of Economics – A Mathematical Analysis*. McGraw-Hill.
Varian H.R. 1992. *Microeconomic Analysis*. W.W Norton & Co.
Varian H.R. 1999. *Intermediate Microeconomics*. Affiliated East-West Press.

AG ECON 612

Advanced Macro Economics Analysis

3(3+0)

Objective

To understand the macroeconomic theory, Policy issues and to analyze the policy implications.

Theory

Review of Macro-Economics concepts-Comparative statistics- Keynesian theory- Consumption Function and

Theories of Consumption –Saving . Function and Theories of Saving. Theories of Investment-Savings and Investment Equality - IS – LM. Framework and its demand for and Supply of Money-Monetary Policy in the static model – Inflation. Stagflation and Supply side Economics - Theory of Unemployment - Phillips Curve controversy - Inflation, Productivity and distribution – Fiscal policy: Effectiveness and Problems. Social Accounting Matrix Framework - General Equilibrium Analysis - Neo classical Macro Economics - Stochastic Macro Economics. BOP & Adjustment Policies - Foreign Exchange Policy - Foreign sector : Capital and Current Account - Impact of WTO on Indian Economy - Impact of IMF & IBRD on Indian Economy - Review of Macro Economic Policies in India.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Review of Macro –Economic Concepts	2
2.	Comparative statistics	2
3.	Keynsian theory	2
4.	Consumption function and theory of consumptions	2
5.	Saving function and theories of saving	2
6.	Theories of investment , saving and investment equality	2
7.	I –S Lm farm work and its demand for supply of money Money supply in static model	2
8.	Money supply model in static model	2
9.	Inflation	2
10.	Stag flation and supply side economics	2
11.	Theory of unemployment	2
12.	Philiph-curve controversy	2
13.	Inflation, productivity and distribution	2
14.	Fiscal policy, effectiveness and problem	2
15.	Social accounting matrix framework	2
16.	General equilibrium analysis	2
17.	Neo classical macro –economics	2
18.	Stochastic macro economics	2
19.	Balance of payment and adjustment policy	2
20.	Foreign exchange policy, foreign sector	2
21.	. Capital and current account	2
22.	. Impact of WTO on Indian Economy	2
23.	IMPACT OF IMF and IBRD on Indian Economy	2
24.	Review of macro – economic policies in India	2
	Total	48

Suggested Readings

- Diulio E.A. 2006. *Macroeconomics*. 4th Ed. Schaums’ Outlines.
 Frogen R.T. 1999. *Macro Economic: Theory and Policies*. 6th Ed. Prentice Hall.
 Samuelson P.A & Nordhaus WD. 2004. *Economics* . McGraw-Hill.
 Shapiro E. 1989. *Macro Economic Analysis*. Galgotia Publ

AG ECON 621 Advanced Agricultural Marketing and Price Analysis 3(2+1)

Objective

The main Course Objective of this course is to critically analyze the important marketing concepts, models, properties of agricultural commodity prices and forecasting, data collection and analysis using current software etc., in order to make them policy decisions in the field of agricultural marketing.

Theory

Importance of market analysis in the agricultural system - types of marketing- advantages and disadvantages - quantitative estimation – the distinguishing characteristics and role of agricultural prices – data sources for agricultural products and prices - softwares used in market analysis. Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership – institutional arrangements. Successful case studies. Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the

changing agrifood system.

Agricultural commodity marketing - spot and futures- marketing of derivatives-speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity, markets-Regulatory mechanism of futures trading. Lag operators and difference equations; stationary and stochastic processes; UNIT roots and cointegration; conditional heteroscedasticity: ARCH and GARCH models – forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

Practical

Estimation of demand/ supply forecasting, supply chain / value chain analysis for different commodities - Commodity models- multi market estimation- time series analysis - market integration studies- price discovery price volatility estimation – commodity price forecasting using econometric softwares.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Importance of market analysis in agriculture system	1
2.	Types of market	1
3.	Advantage and disadvantage of market types	1
4.	Quantitative estimation	1
5.	The distinguishing characteristics and role prices	1
6.	Data sources for agricultural products and prices	1
7.	Software's used in market analysis	1
8.	Role of various formal institution in agricultural market and functions	1
9.	Measuring their efficiency	1
10.	Public private partnership institutional arrangements	1
11.	Multimarket estimates	1
12.	Supply response models	1
13.	Market integrations and price transmission	1
14.	Supply and value chain management	1
15.	Gap analysis	1
16.	Current trendo in information in the changing agrifood system	1
17.	Agricultural commodity marketing spot – and futures	1
18.	Marketing of derivatives speculation heading , swap, arbitrage etc.	1
19.	Commodity exchange	1
20.	. Price – discovery	1
21.	Risk management in commodity markets	1
22.	Regulatory mechanism of future trading	1
23.	Lay operators and difference equations	1
24.	Stationary and stochastic process	1
25.	Roots and co integration	1
26.	Conditional hetero scadastocity	1
27.	ARCH MMODELS	1
28.	GARCH MODEL	1
29.	Forecast evaluation	1
30.	Methods of forecast	1
31.	Prices indices	1
32.	Econometrics estimation and simulation	1

Lecture schedule: Practical

S.No.	Topics	No. of lectures
1	Estimation of demand	1
2	Estimation of supply	1
3	Supply chain / Value chain analysis of different commodities1	2
4	Commodity models	2
5	Multimarket estimation	2
6	Time series analysis	2
7	Market integration studies	2
8	Prices discover	2

9	Price –valatility	1
10	Commodity price forecasting use of econometric soft wares	1
	Total	16

Suggested Readings

- Ferris J.N. 1998. *Agricultural Prices and Commodity Market Analysis*. McGraw-Hill
- Goodwin J.W. 1994. *Agricultural Price Analysis and Forecasting*. Wiley.
- Hallam D. 1990. *Econometric Modeling of Agricultural Commodity Markets*. New Routledge.
- Martimort D. (Ed.). 1996. *Agricultural Markets: Mechanisms, Failures, and Regulations*. Elsevier.
- Schrimper. R.A. 2001. *Economics of Agricultural Markets*. Pearson.
- Timmer .C.P. 1986. *Getting Prices Right*. Cornell University Press.
- Tomek W.G & Robinson K.L. 2003. *Agricultural Product Prices*. 4th Ed. Cornell University Press.

AGECON 622

Advanced Production Economics

3(2+1)

Objective

To expose the students to the concept, significance and uses of advance production economics.

Theory

Agricultural Production process – Relationship between farm planning and production economics-scope of agricultural production and planning- methods/procedures in agro-economic research and planning. Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance – Production relations – optimality-Commonly used functional forms, nature, properties, limitations, estimation and interpretation - linear, Spillman -Cobb Douglas, quadratic, multiplicative (power) functional forms, transcendental functional forms -CES, production functional forms- Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum - Economic optimum with production function analysis - input use behaviour. 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. Principles and derivation of demand and supply functions. Technology, input use and factor shares - effect of technology on input use- decomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement -Yield gaps analysis – concepts and measurement - Risk and uncertainty in agriculture – incorporation of risk and uncertainty in decision making – risk and uncertainty and input use level. Simulation and programming techniques in agricultural production.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations. Estimation of factor shares from empirical functions estimated. Decomposition analysis. Simulation models for agricultural production decisions.

Lecture schedule: Theory

S.No.	Topics	No. of lectures
1.	Agricultural Production process – Relationship between farm planning and production economics	2
2.	Scope of agricultural production and planning methods/procedures in agro-economic research and planning.	2
3.	Production functions, components, assumptions, properties and their economic interpretation-Concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance.	3
4.	Production relations – optimality – Commonly used functional forms, nature, properties, limitations, estimation and interpretation – linear, Spillman – Cobb Douglas, quadratic, multiplicative (power) functional forms, transcendental functional forms – CES production functional forms.	5
5.	Conceptual and empirical issues in specification, estimation and application of production functions.	2
6.	Analytical approaches to economic optimum – Economic optimum with production function analysis – input use behaviour. Decision making with multiple inputs and outputs.	2
7.	MRT and product relationship – cost of Production and adjustment in output prices –	2

	single input and multiple product decisions.	
8.	Principles and derivation of demand and supply functions	2
9.	Technology, input use and factor shares – effect of technology on input use	2
10.	Decomposition Analysis- factor shares – estimation methods	2
11.	Economic efficiency in agricultural production – technical, allocative and economic efficiency – measurement	2
12.	Yield gaps analysis	1
13.	Concepts and measurement of risk and uncertainty in agriculture	1
14.	Incorporation of risk and uncertainty in decision making	1
15.	Risk and uncertainty and input use level.	1
16.	Simulation and programming techniques in agricultural production.	2
17.	Total	32

Lecture schedule: Practical

S.No.	Topics	No. of lectures
1.	Estimation of different forms of production functions	4
2.	Optimal input and product choice from estimated functions	2
3.	Derivation of demand and supply functions and estimation	2
4.	Estimation of cost function and interpretations	2
5.	Estimation of factor shares from empirical functions estimated.	2
6.	Decomposition analysis	2
7.	Simulation models for agricultural production decisions	2
	Total	16

Suggested Readings

Chambers R.G. 1988. *Applied Production Analysis*. Cambridge Univ. Press.

Gardner B.L & Rausser G.C. 2001. *Handbook of Agricultural Economics*. Vol. IA *Agricultural Production*. Elsevier.

Palanisami K.P, Paramasivam & Ranganathan CR. 2002. *Agricultural Production Economics: Analytical Methods and Applications* Associated Publishing Co.

List of Journals

- Agricultural Economics Research Review
- Agricultural Finance Review
- Agricultural Marketing
- Agriculture and Agro-industries Journal
- Agriculture Statistics at a Glance
- APEDA Trade yearbook
- Asian Economic and Social Review (Old Series)
- Bulletin of Agricultural Prices
- Economic and Political Weekly
- Economic Survey of Asia and Far East
- FAO Commodity Review and Outlook
- FAO Production Year book
- FAO Trade year book
- Indian Cooperative Review
- Indian Economic Journal
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Economics

- International Food Policy Research Institute Research Report
- Journal of Agricultural Development and Policy
- Journal of Agricultural Economics
- Journal of Agricultural Economics and Development
- Journal of Farm Economics
- Land Economics • Productivity
- Reserve Bank of India Bulletin
- Rural Economics and Management
- World Agricultural Economics and Rural Sociology Abstracts
- World Agricultural Production and Trade: Statistical Report

e-Journals

- www.pearsoned.com (Pearson Education Publication)
- www.mcgraw-hill.com (McGraw-Hill Publishing Company)
- www.oup.com (OxfordUniversity Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage publications)
- www.isaeindia.org (Indian Society of AgriculturalEconomics)
- www.macmillanindia.com (Macmillan Publishing)
- www.icar.org.in (Indian Council of Agricultural Research)
- www.khoj.com (Directory for Agricultural Economics)
- www.ncap.res.in (National Centre for Agril. Economics and Policy Research)
- www.ncdex.com (National Commodity & Derivatives Exchange Limited)
- www.phdcci.in (PHD Chamber of Commerce and Industry)
- www.ficci.com (Federation of Indian Chambers of Commerce and Industry)
- www.assochem.org (Associated Chambers of Commerce and Industry of India)
- www.apeda.com (Agril. and Processed Food Products ExportDevel. Autho)
- www.mpeda.com (Marine Products Export Development Authority)

Biochemistry

M.Sc. Programme

I Semester

Course No.	Course title	Credit hours
BIOCH-511	Basic Biochemistry	3(2+1)
BIOCH-512	Techniques in Biochemistry	3(2+1)
BIOCH-513	Intermediary Metabolism-I	3(3+0)

II Semester

BIOCH-521	Plant Biochemistry	3 (2+1)
BIOCH-522	Intermediary Metabolism-II	3 (3+0)
BIOCH-523	Enzymology	3 (2+1)
BIOCH-524	Molecular Biology	3 (3+0)

III Semester ,M.Sc.(Ag)

BIOCH-531	Biochemistry of Biotic and Abiotic Stress in Plants	3 (3+0)
BIOCH-532	Recombinant DNA Technology	3 (2+1)

IV Semester

BIOCH 541	M.Sc. Seminar	1(0+1)
BIOCH 542	M.Sc. Comprehensive	2(0+2)
BIOCH 543	M.Sc. Research	15

BIOCH 511

Basic Biochemistry

3(2+1)

Objective

To provide elementary knowledge of structure, functions and metabolism of biomolecules.

Theory:

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces, classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids, structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Hormones – animal, plants and insects, metabolism of carbohydrates, lipids, proteins. Oxidative phosphorylation. DNA replication, transcription and translation. Recombinant DNA technology.

Practical:

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by diphenylamine and orcinol methods, Estimation of Ascorbic acid, Separation of biomolecules by TLC and Paper chromatography.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Scope and importance of biochemistry in agriculture.	1
2	Fundamental principles governing life.	1
3	Structure of water; acid base concept and buffers; pH.	1
4	Hydrogen bonding; hydrophobic, electrostatic and Vander Waals forces	1
5	Classification, structure and function of carbohydrates	1
6	Classification, structure and function of lipids, Bio-membranes	2
7	Classification and structure of amino acids.	1
8	Properties and general reaction of amino acids.	1
9	Classification and structure of proteins.	1
10	Nucleic acids- Nucleosides, Nucleotides and structure of DNA and RNA	2
11	Classification of DNA and RNA.	1
12	Vitamins- Structure and classification	1
13	Biological functions of vitamins, Co-enzyme.	1
14	Enzymes- Classification and mechanism of action	1
15	Regulation and factors affecting enzyme action.	1
16	Inhibitors of enzymes	1
17	Hormones – Classification and mode of action in Animal.	1
18	Hormones - Classification and mode of action in, plants and insects	2
19	Differences of hormone in Animals, Plants and Insects	1
20	Metabolism of carbohydrates- Glycolysis and its regulation	1
21	Kreb's cycle and its regulation.	1
22	Biosynthesis of sucrose and starch	1
23	Biosynthesis of Fatty acids and glycerols	1
24	Elementary concept of protein synthesis – translation	1
25	Oxidative phosphorylation	1
26	DNA replication, transcription	2
27	Recombinant DNA technology concept	2

Lecture schedule: Practical

S. No.	Topic	No. of lectures
1	Preparation of standard and buffer solutions.	2
2	Extraction and estimation of sugars	1
3	Estimation of Total Amino acids.	1
4	Estimation of Proteins by Lowry's method	2
5	Estimation of DNA.	2
6	Estimation of RNA by diphenylamine and orcinol methods	2
7	Estimation of Ascorbic acid	1
8	Separation of biomolecules by TLC.	3
9	Paper chromatography	2

Suggested Readings

Conn EE & Stumpf PK. 1999. Outlines of Biochemistry. John Wiley.
 Metzler DE. 2006. Biochemistry. Vols. I, II. Wiley International.
 Nelson DL & Cox MM. 2007. Lehninger Principles of Biochemistry. 5th Ed. MacMillan.
 Voet D, Voet J G & Pratt CW. 2007. Fundamentals of Biochemistry. John Wiley.

BIOCH 512

Techniques in Biochemistry

3(2+1)

Objective

To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents.

Theory:

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & column chromatography, HPTLC, Gas-liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) – native, SDS-PAGE, 2D-PAGE, and capillary electrophoresis, Spectrophotometry: Principles and applications UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy. circular dichromism and optical rotatory dispersion, fundamentals, application and experimental techniques polarization, Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation- their principles, variants and applications. Preparative, density gradient and ultracentrifugation. Analysis of sub-cellular fraction. Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods. Concept of α , β and γ emitters, scintillation counters, γ -ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

Practical:

Estimation of biomolecule using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer chromatography. Separation of proteins by gel filtration and Electrophoresis. Analysis of fatty acids by GLC. Analysis of steroids by HPLC.s.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Chromatographic- Principles, Methods and applications of Paper & Thin layer chromatography.	2
2	Column chromatography- Methods and applications.	1
3	Gas-liquid chromatography (GLC)- Instrumentation, methods and applications.	2
4	HPLC- Principle, instrumentation, Practical procedure and application.	2
5	FPLC & HPTLC- Principle and applications	1
6	Electrophoresis- Principles, methods of separation of Paper and gel electrophoresis	2
7	Different variants of polyacrylamide gel electrophoresis (PAGE).	1
8	Native PAGE & SDS-PAGE- Apparatus and applications	2
9	2D-PAGE- Apparatus and applications	1
10	Capillary electrophoresis- Principle and methods	1
11	Spectrophotometry: Principles and applications UV-Visible Spectrophotometry	1
12	Fluorescence IR and FTIR- Principle and applications	1
13	Raman, NMR- Principle and applications.	1
14	FTNMR, ESR- Principle and applications	1
15	X-Ray spectroscopy- Principle, methods and applications	1
16	Circular dichromism and optical rotatory dispersion fundamentals, application and experimental techniques polarization	1
17	Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation- their principles, variants and applications.	1
18	Preparative & density gradient centrifugation	2
19	Ultracentrifugation- Principle and applications.	1
20	Analysis of sub-cellular fraction	1
21	Tracer techniques in biology: Concept of radioactivity	1
22	Radioactivity counting methods	1
23	Concept of α , β and γ emitters	1
24	Scintillation counters, γ -ray spectrometers	1
25	Autoradiography, applications of radioactive tracers in biology	1
26	Principles and applications of phosphor imager	1

Lecture schedule: Practical

S. No.	Topic	No. of lectures
1	Estimation of biomolecule using spectrophotometer	2
2	Separation of carbohydrates and amino acids by paper chromatography	3
3	Separation of lipids by thin layer chromatography	2
4	Separation of proteins by gel filtration and Electrophoresis	3
5	Analysis of fatty acids by GLC	3
6	Analysis of steroids by HPLC	3

Suggested Readings

- Clark JM. 1977. *Experimental Biochemistry*. 2nd Ed. WH Freeman.
Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa.
Willard M, Merritt LL & Dean JA. 1981. *Instrumental Methods of Analysis*. 4th Ed. Van Nostrand.
William BL & Wilson K. 1975. *Principles and Techniques of Practical Biochemistry*. Edward Arnold.
Wilson K, Walker J & Walker JM. 2005. *Principles and Techniques of Practical Biochemistry*. Cambridge Univ. Press.

BIOCH 513

Intermediary Metabolism- I

3(3+0)

Objective

To impart knowledge of metabolic pathways of carbohydrates and lipids and their regulation.

Theory:

Introduction to metabolism, methods of studying metabolism, metabolic transport mechanism, bioenergetics, biological oxidation, signal transduction- endocrine, exocrine and synaptic signaling molecules, surface and intracellular receptors, G protein and secondary messengers, cAMP, Ca⁺⁺ and calmodulin, Carbohydrate metabolism. Glycolysis- reaction sequences and regulation, metabolism of other hexoses, glycogen-breakdown, and control, glucouronate pathway, Kerb's cycle, anaplerotic and amphipathic nature of Kerb's cycle, glyoxylate pathway, HMP pathway, Entener-Duoderoff pathway, Biosynthesis of carbohydrates- gluconeogenesis, glycogen biosynthesis, phosphorylation, electron transport chain and ATP synthase system, Lipids metabolism: saturated and unsaturated Fatty Acid degradation., acylglycerols, phosphoglycerides and sphingolipids such as sphingomylin, cerebrosides and gangliocides, ketone bodies synthesis and degradation, fatty acid biosynthesis, actetyl CoA carboxylase, fatty acid synthetases, biosynthesis of unsaturated fatty acids, biosynthesis of triacylglycerol, phosphoglycerol and sphingolipids, biosynthesis of steroids. terpenes and eicosanoids, Carbohydrate and lipid metabolism regulations and disorders, carbohydrate and lipid metabolic profiles of major organs, Metabolic engineering concepts.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Introduction to metabolism, methods of studying metabolism, metabolic transport mechanism	2
2	Bioenergetics and biological oxidation	2
3	Signal transduction- endocrine, exocrine and synaptic signaling molecules, surface and intracellular receptors	2
4	G protein and secondary messengers, cAMP, Ca ⁺⁺ and calmodulin.	2
5	Carbohydrate metabolism. Glycolysis- reaction sequences and regulation.	1
6	Metabolism of other hexoses, glycogen breakdown and its control	2
7	Glucouronate pathway	1
8	Kerb's cycle, anaplerotic and amphipathic nature of Kerb's cycle.	2
9	Glyoxylate pathway, HMP pathway	2
10	Biosynthesis of carbohydrates- Gluconeogenesis	2
11	Glycogen biosynthesis	2
12	Oxidative phosphorylation.	1
13	Electron transport chain and ATP synthase system.	2
14	Lipids metabolism: saturated and unsaturated Fatty Acid degradation.	2
15	Acylglycerols, phosphoglycerides metabolism.	2
16	Sphingolipids such as sphingomylin, cerebrosides and gangliocides	2
17	Ketone bodies synthesis and degradation	1
18	Fatty acid biosynthesis, acetyl CoA carboxylase, fatty acid synthetases	2
19	Biosynthesis of unsaturated fatty acids	2
20	Biosynthesis of triacylglycerol, phosphoglycerol and sphingolipids	2
21	Biosynthesis of steroids	2
22	Biosynthesis of Terpenes and eicosanoids.	2
23	Carbohydrate regulations and disorders	2
24	Lipid metabolism regulations and disorders	2
25	Carbohydrate and lipid metabolic profiles of major organs.	2
26	Metabolic engineering concepts	2

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman & Co.
Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.
Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.
Zubey GL. 1998. *Biochemistry*. 4th Ed. WCB London.

BIOCH 521

Plant Biochemistry

3 (2+1)

Objective

Detailed information about biochemical and molecular basis of various plant processes and plant growth regulatory substances.

Theory:

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function. Photosynthetic pigments, photosynthesis, C₃, C₄ and CAM pathways, photorespiration, Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur into amino acids, Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction, Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Practical:

Estimation of chlorophyll, protein by Lowry's method and starch. Estimation of nitrate content by hydrazine sulphate reduction method. *In vivo* assay of nitrate reductase activity, Assay of nitrogenase activity by acetylene reduction method.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Scope and importance of Biochemistry in Agriculture	1
2	Plant cell organelles and their separation, structure and function	1
3	Photosynthesis- Photosynthetic pigments.	2
4	Calvin cycle (C ₃ pathway)	1
5	C ₄ and CAM pathways	1
6	Photorespiration.	1
7	Sucrose-starch interconversion	1
8	Biosynthesis of structural carbohydrates	2
9	Biosynthesis of storage proteins and lipids	2
10	Biochemistry of nitrogen fixation and nitrate assimilation	3
11	Sulphate reduction and incorporation of sulphur into amino acids	2
12	Biochemistry of seed germination and development	2
13	Biochemistry of fruit ripening	1
14	Phytohormones and their mode of action, signal transduction.	3
15	Biochemistry and significance of secondary metabolites	1
16	Cyanogenic glycosides, glucosinolates	1
17	Biochemistry and significance of Phenolic compounds	2
18	Biochemistry and significance of Terpenoids	1
19	Biochemistry and significance of alkaloids.	2
20	Role of secondary metabolites in plant defense system.	2

Lecture schedule: Practical

S. No.	Topic	No. of lectures
1	Estimation of chlorophyll	2
2	Estimation of Protein by Lowry's method	2
3	Estimation of starch	3
4	Estimation of nitrate content by hydrazine sulphate reduction method	3
5	<i>In vivo</i> assay of Nitrate Reductase activity.	3
6	Assay of nitrogenase activity by acetylene reduction method	3

Suggested Readings

- Buchanan BB, Grussem W & Jones RL. 2000. *Biochemistry and Molecular Biology of Plants*. 2nd Ed. John Wiley.
- Dey PM & Harborne JB. 1997. *Plant Biochemistry*. Academic Press.
- Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*. Pergamon Press.
- Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ. Press.
- Lea PJ & Leegood RC. 1993. *Plant Biochemistry and Molecular Biology*. 2nd Ed. John Wiley.

BIOCH 522

Intermediary Metabolism -II

3(3+0)

Objective

To impart knowledge of metabolic pathways of amino acids, proteins and nucleic acids in respect to their regulation.

Theory

Nitrogen cycle, nitrification and denitrification process with characteristics of organisms capable of these processes, biological nitrogen fixation- nitrogen fixing organisms(symbionts and nonsymbionts), characteristics features of nitrogenase, its mechanism and nitrogen fixation regulation by *nif* gene expression, General reactions of amino acid metabolism- Mechanisms of transamination, decarboxylation, deamination and racemization etc., Pyridoxal phosphate- structure and its role in general amino acid metabolism with reaction mechanism, assimilation of amino acids, ammonia excretion, urea cycle and their regulation, Degradation and biosynthetic pathways of protein amino acids operating in animals, plants and microbes and their regulation, Porphyrine metabolism, Biosynthesis of biogenic amines e.g. histamine, serotonin, melatonin, GABA shunt, Metabolism of xenobiotic and detoxification mechanism, Degradation of pyrimidines, purines and their nucleotides, biosynthesis of pyrimidines and purines by *de novo* and salvage pathways, Synthesis of thymidine, deoxyribose and deoxyribonucleotides and metabolism of nucleotide coenzymes, regulation of purine and pyrimidines metabolisms, inborn errors of metabolism, integration of metabolism.

Lecture schedule: Theory

S. No.	Topic	No. of Lectures
1	Nitrogen cycle.	2
2	Nitrification and denitrification process with characteristics of organisms involved in these processes.	2
3	Biological nitrogen fixation- nitrogen fixing organisms(symbionts and nonsymbionts)	3
4	Characteristics features of nitrogenase	2
5	Nitrogenase mechanism	1
6	Nitrogen fixation regulation by <i>nif</i> gene expression	3
7	General reactions of amino acid metabolism- Mechanisms of transamination, decarboxylation, deamination and racemization	2
8	Pyridoxal phosphate- structure and its role in general amino acid metabolism with reaction mechanism	2
9	Assimilation of amino acids, ammonia excretion	3
10	Urea cycle and its regulation	1
11	Degradation and biosynthetic pathways of protein amino acids operating in animals, plants and microbes and their regulation	3
12	Porphyrine metabolism	2
13	Biosynthesis of biogenic amines e.g. histamine, serotonin, melatonin, GABA shunt	3
14	Metabolism of xenobiotic and detoxification mechanism	2
15	Degradation of pyrimidines, purines and their nucleotides	3
16	Biosynthesis of pyrimidines and purines by <i>de novo</i> and salvage pathways	4
17	Synthesis of thymidine, deoxyribose and deoxyribonucleotides	3
18	Metabolism of nucleotide coenzymes	2
19	Regulation of purine and pyrimidines metabolisms	3
20	Inborn errors of metabolism, integration of metabolism	2

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman & Co.
Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.
Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.
Zubey GL. 1998. *Biochemistry*. 4th Ed. WCB London.

BIOCH 523

Enzymology

3(2+1)

Objective

To impart knowledge about the catalytic role of enzymes, their structure, physico-chemical, kinetic and regulatory properties and mechanism of action.

Theory :

Introduction and historic perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, measurement of enzyme activity. ribozymes, isozymes, abzymes, Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role, Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes, allosteric enzymes and their kinetics, regulation of enzyme activity, Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical:

Enzyme assay of alpha-amylase. Isolation and purification of acid phosphatase. Effect of substrate concentrations on enzyme activity- alpha-amylase or acid phosphatase. Determination of pH and temperature optima of peroxidase. Determination of the pH and temperature optima of nitrate reductase.

Lecture schedule: Theory

S. No.	Topic	No. of Lectures
1	Introduction and historic perspective of Enzymology	1
2	Enzyme nomenclature and classification.	2
3	Enzyme compartmentalization in cell organelles	2
4	Measurement of enzyme activity	1
5	Ribozymes, isozymes, abzymes	2
6	Enzyme structure	1
7	Enzyme specificity	2
8	Active site, active site mapping.	2
9	Mechanism of enzyme catalysis	2
10	Cofactors, coenzymes- their structure and role.	2
11	Enzyme kinetics	2
12	Enzyme inhibition and activation.	2
13	Multienzyme complexes, allosteric enzymes and their kinetics	1
14	Regulation of enzyme activity	2
15	Isolation and purification of enzymes.	2
16	Applications of enzymes in chemical and food industry	2
17	Enzyme immobilization	2
18	Biosensors and clinical applications of enzymes	2

Lecture schedule: Practical

S. No.	Topic	No. of Lectures
1	Enzyme assay of alpha-amylase.	2
2	Isolation and purification of acid phosphatase.	4
3	Effect of substrate concentrations on enzyme activity- α -amylase or acid phosphatase	2
4	Determination of pH and temperature optima of peroxidase.	4
5	Determination of the pH and temperature optima of nitrate reductase	4

Suggested Readings

Bergmeyer HU. 1983. *Methods of Enzymatic Analysis*. Vol. II. Verlag Chemie, Academic Press.
Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. *Enzymes*. 3rd Ed. Longman.

- Maragoni AG. 2003. Enzyme Kinetics - A Modern Approach. John Wiley.
- Palmer T. 2001. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. 5th Ed. Horwood Publ.
- Price NC & Stevens L. 2003. Fundamentals of Enzymology. Oxford Univ. Press.
- Wilson K & Walker J. (Eds.). 2000. Principles and Techniques of Practical Biochemistry. 5th Ed. Cambridge Univ. Press.

BIOCH 524

Molecular Biology

3(3+0)

Objective

To provide knowledge regarding genes, their functions, expression, regulation and transfer in heterologous systems.

Theory

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function, DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, inhibitors of replication repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing, Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases', translation and Post translational modification; regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation, Proteomics, Principle and methods of 2D-PAGE, MS, MALI-TOF, Protein microarray, Site directed mutagenesis.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Historical development of molecular biology	1
2	Nucleic acids as genetic material	2
3	Chemistry and structure of DNA and RNA	3
4	Genome organization in prokaryotes and eukaryotes	2
5	Chromatin structure and function	1
6	DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase	3
7	Inhibitors of replication, repetitive and non-repetitive DNA.	2
8	Satellite DNA.	2
9	Transcription process	2
10	RNA editing and RNA processing	3
11	Ribosomes structure and function	2
12	Organization of ribosomal proteins and RNA genes.	2
13	Genetic code.	2
14	Aminoacyl tRNA synthases', translation	2
15	Post translational modification	2
16	Regulation of gene expression in prokaryotes	3
17	Regulation of gene expression in eukaryotes.	2
18	Molecular mechanism of mutation	2
19	Proteomics, Principle and methods of 2D-PAGE	3
20	MS, MALI-TOF.	3
21	Protein microarray	2
22	Site directed mutagenesis	2

Suggested Readings

- Adams RLP, Knowler JT & Leader DP. 1992. The Biochemistry of the Nucleic Acids. 11th Ed. Chapman & Hall.
- Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD 2006. Molecular Biology of the Cell. 6th Ed. Garland Publ.
- Blackburn GM & Gait MJ. 1996. Nucleic Acids in Chemistry and Biology. 2nd Ed. Oxford University Press.
- Freifelder D & Malacinski GM. 1996. Essentials of Molecular Biology. 3rd Ed. Panima.
- Glick BR & Pasternak JJ. 1994. Molecular Biology: Principles and Applications of Recombinant DNA Technology. ASM Press.
- Lewin B. 2007. Genes IX. Oxford University Press.
- Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnell J. 1999. Molecular Cell Biology. WH Freeman.

Old RW & Primrose SB. 1989. Principles of Gene Manipulation: An Introduction to Genetic Engineering. 4th Ed. Blackwell Scientific Publ.
 Sambrook J & Russel DW. 2001. Molecular Cloning: A Laboratory Manual. Vols. I-III. Cold Spring Harbor.

BIOCH 531

Biochemistry of Biotic and Abiotic Stresses

3 (3+0)

Objective

To impart latest development about biochemistry of biotic and abiotic stresses in plants.

Theory:

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants, plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance, Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation, Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes defense system. Role of calcium nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Plant-pathogen interaction and disease development- Different steps and biochemical changes	3
2	Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism.	3
3	Cell wall composition and vascular transport in diseased plants.	3
4	Plant defense response and resistance mechanism	3
5	Antimicrobial molecules- types and their role.	2
6	Genes for resistance, hypersensitive response and cell death	2
7	Systemic and acquired resistance	2
8	Plant viruses- structure and replication	3
9	Plant viruses- movement and interaction and host range determinat	3
10	Viroids, pathogen-derived resistance	3
11	Biochemical basis of abiotic stresses- drought and salinity	4
12	Biochemical basis of abiotic stresses- Temperature, heavy metals, air and water pollutants	3
13	Synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses	3
14	Stress adaptation by plants	2
15	Reactive oxygen species- Formation and its role in stress	2
16	Biotic and abiotic stress, antioxidants (Molecules and Enzymes).	2
17	Enzymes defense system	2
18	Role of calcium nitric oxide and salicylic acid in plant development.	2
19	Molecular strategies for imparting tolerance against biotic and abiotic stress	2

Suggested Readings

Basra AS. 1997. *Stress Induced Gene Expression in Plants*. Harwood Academic Publ.
 Chessin M, DeBorde D & Zipf A. 1995. *Antiviral Proteins in Higher Plants*. CRC Press.
 Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. *Gene-for-Gene Relationship in Host-Parasite Interactions*. CABI.

Objective

To provide insight into various methods of gene cloning and their application.

Theory

Structure of DNA; Function of genes and genomes; Restriction enzymes and vectors; Methods of gene isolation and cloning. Nucleic acid hybridization; PCR and its applications; Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genomics and transcriptomics, Genetic engineering methods and transgenics. Application of genetic engineering in Agriculture, Medicine, Forensics. Site directed mutagenesis, gene targeting, gene therapy. Biotechnology; Bio-safety and bioethics issues; Intellectual property rights in recombinant DNA research.

Practical

Isolation and purification of DNA and RNA from different sources, Purity check of isolated DNA and RNA. Restriction fragmentation and separation of DNA by agarose electrophoresis. RAPD analysis of DNA, cDNA synthesis using PCR, Southern and Northern blotting experiments.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Structure of DNA	1
2	Function of genes and genomes	1
3	Restriction enzymes and vectors	3
4	Methods of gene isolation and cloning	3
5	Nucleic acid hybridization	1
6	PCR and its applications	2
7	Molecular markers and their applications	3
8	DNA sequencing	2
9	Applications of gene cloning in basic and applied research	2
10	Genomics and transcriptomics	2
11	Genetic engineering methods and transgenics	3
12	Application of genetic engineering in Agriculture, Medicine, Forensics	2
13	Site directed mutagenesis	1
14	Gene targeting, gene therapy	2
15	Biotechnology; Bio-safety and bioethics issues	2
16	Intellectual property rights in recombinant DNA research	2

Lecture schedule: Practical

S. No.	Topic	No. of lectures
1	Isolation and purification of DNA	1
2	Isolation and purification of RNA from different sources	1
3	Purity check of isolated DNA and RNA	1
4	Restriction fragmentation and separation of DNA by agarose electrophoresis	2
5	RAPD analysis of DNA	3
6	cDNA synthesis using PCR	4
7	Southern blotting technique	2
8	Northern blotting experiments	2

Suggested Readings

Molecular biology (2005) by David P. Clark.

Molecular biology of the Cell (2008) by Bruce Alberts.

Molecular biology and Biotechnology (2009) by John M. Walker, Ralph Rapley

Biotechnology: Expanding Horizons (2010) by B D Singh.

List of Journals

- Annual Review of Biochemistry
- Annual Review of Genetics
- Annual Review of Plant Physiology and Plant Molecular Biology
- Biochemical and Biophysical Research Communication
- Biochemical Journal
- Biochim. Biophysic Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Indian Journal of Experimental Biology
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modeling
- Journal of Plant Biochemistry and Biotechnology
- Nature
- Physiologia Plantarum
- Plant Physiology
- Plant Science
- Planta
- Proceedings of National Academy of Sciences, USA
- Protein Science
- RNA
- Science
- Scientific American
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Plant Sciences

e-Resources

- www.unixl.com/dir/molecular_sciences/biochemistry/biochemistry_jobs/
- www.unixl.com/dir/medical_sciences/
- <http://www.ncbi.nlm.nih.gov/>
- <http://us.expasy.org>
- <http://us.expasy.org/spdbv/>
- <http://www.brenda.uni-koeln.de/>
- <http://www.worthington-biochem.com>
- <http://www.cefotaxime.net>
- <http://home.123india.com/nbsc/>
- <http://www.biochemist.org>
- <http://www.gwu.edu/~mpb>

ENTOMOLOGY

M.Sc.(Ag)

Semester-I		
ENT 511 [§]	Insect Morphology	2+1
ENT 512*	Insect Ecology	2+1
ENT 513 [§]	Principles of Integrated Pest Management	2+1
Semester-II		
ENT 521 [§]	Classification of Insects	2+1
ENT 522 [§]	Insect Physiology And Nutrition	2+1
ENT 523*	Toxicology of Insecticides	2+1
ENT 524*	Pests of Field Crops	2+1
Semester-III		
ENT 531*	Pests Of Horticultural and Plantation Crops	2+1
ENT 533*	Biological Control of Crop Pests and Weeds	2+1
Semester-IV		
ENT 541	Master's Seminar	0+1
ENT 542	Comprehensive	0+2
ENT 543	Master's Research	15

Ph.D

Semester-I		
ENT 611 [§]	Molecular Approaches In Entomological Research	3+0
ENT 612	Advanced Insect Physiology	3+0
Semester-II		
ENT 621 [§]	Advanced Integrated Pest Management	3+0
ENT 622	Recent Trends In Biological Control	2+1
Semester-III		
ENT 641	Doctoral Seminar	2
ENT 642	Preliminary	4
ENT 643	Doctoral Research	40

[§] Core courses

*Compulsory courses

List of minor courses:

M.Sc.(Ag)

Semester-I		
STAT 511	Statistical Methods For Applied Sciences	2+1
PPATH 513	Principles of Plant Pathology	3+0
Semester-II		
BIOCHEM 521	Basic Biochemistry	2+1
Semester-III		
PPATH 532	Principles of Plant Disease Management/	2+1
PPATH 533	Disease Of Field and Medicinal Plants	2+1

Ph.D

Semester-I		
BIOCHEM 532	Biochemistry Of Biotic and Abiotic Stress	3+0
PPATH 512	Detection and Diagnosis Of Plant Diseases	0+3
Semester-II		
NEMAT 521	Nematode Diseases of Crops	2+1
PPATH 523	Diseases of Vegetables and Spice Crops	2+1

ENT 511**Insect Morphology****3(2+1)****Objective**

To acquaint the students with external morphology of the insect's body i.e., head, thorax and abdomen, their appendages and functions. To study the anatomy of different systems.

Theory

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation, Head- Origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites, Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications, Abdomen-Segmentation and appendages; Genitalia and their modifications; embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemo- receptors), Structure of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

Practical:

Dissection of cockroach/ grass hopper to study comparative anatomical details of different systems. Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Sense organs.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Principles, utility and relevance of insect body wall structure and cuticular outgrowths	1
2	Colouration and special integumentary structures in insects	1
3	Insect body tagmata, sclerites and segmentation	1
4	Origin, structure and modification of Head	1
5	Types of mouthparts	3
6	Types of antennae	1
7	Tentorium and neck sclerites	1
8	Areas and sutures of tergum, sternum and pleuron, pterothorax	1
9	Structure and modifications of Wings	1
10	Wing venation	1
11	Wing coupling apparatus and mechanism of flight	2
12	Structure and modifications of Legs	2
13	Segmentation and appendages of abdomen	1
14	Genitalia and their modifications	2
15	Embryonic and post-embryonic development	1
16	Types of metamorphosis	1
17	Insect sense organs (mechano-, photo- and chemo- receptors)	2
18	Structure and function of digestive systems	1
19	Structure and function of circulatory systems	1

20	Structure and function of respiratory systems	1
21	Structure and function of excretory systems	1
22	Structure and function of nervous systems	1
23	Structure and function of sensory organ	1
24	Structure and function of reproductive systems	1
25	Structure and function of musculature	1
26	Structure and function of endocrine and exocrine glands	1

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1	Study of insect segmentation	1
2	Study of various tagmata and their appendages	1
3	Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia	6
4	Study of Sense organs	1
5	Dissection of cockroach to study comparative anatomical details of digestive , nervous, excretory systems	7

Suggested Readings

- Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge.
- David BV & Ananthkrishnan TN. 2004. *General and Applied Entomology*. Tata-McGraw Hill, New Delhi.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publ., New Delhi.
- Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi.
- Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.
- Saxena RC & Srivastava RC. 2007. *Entomology: At a Glance*. Agrotech Publ. Academy, Jodhpur.
- Snodgrass RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

ENT 512

Insect Ecology

3(2+1)

Objective

To teach the students the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, constructing life tables, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

History and Definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology, Basic concepts of abundance- Model vs Real world. Population growth- basic models – Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation, Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain-web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-

Volterra model, Concept of niche- ecological homologues, competitive exclusion. Prey-predator interactions- Basic model- Lotka-Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies, Community ecology-Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w , Relation between the two and their association with Dyar's Law and Prizbram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity-stability debate, relevance to pest management. Pest management as applied ecology.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1	History and definition , Basic Concept	1
2	Organisation of the Biological world	1
3	Plato's Natural balance vs Ecological Dynamics as the modern view	1
4	Abundance and diversity of insects, Estimates and causal factors	1
5	Study of abundance and distribution and relation between the two	1
6	Basic principles of abiotic factors and their generalised action on insects	1
7	Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance and biocoenosis, System approach to ecology	2
8	Basic concepts of abundance- Model vs Real world	1
9	Population growth – basic models –Exponential vs Logistic models	1
10	Discrete vs Continuous growth models	1
11	Concepts of Carrying capacity, Environment Resistance and Optimal yield	1
12	Vital Statistics – Life Tables and their application to insect biology	1
13	Survivorship curves	1
14	Case studies of insect life tables	1
15	Population dynamics – Factors affecting abundance – Environmental factors, dispersal and migration, seasonality in insects	1
16	Classification and mechanisms of achieving different seasonality – Diapause (Quiescence) – aestivation, hibernation	1
17	Biotic factors – Food as a limiting factor for distribution and abundance, Nutritional Ecology	1
18	Food chain – web and ecological succession	1
19	Interspecific interactions – Basic factors governing the interspecific interactions – Classification of interspecific interactions – The argument of cost- benefit ratios	2
20	Competition – Lotka – Volterra model, Concept of niche – ecological homologues, competitive exclusion	1
21	Prey – predator interactions – Basic model – Lotka – Volterra Model, Volterra's principle	1
22	Functional and numerical response	1
23	Defense mechanisms against predators/parasitoids –Evolution of mimicry, colouration	1
24	Concept of predator satiation ; evolution of life history strategies	1
25	Community ecology – concept of guild	1
26	Organisation of communities – Hutchinson Ratio, May's d/w , Relation between the two and their association with Dyar's Law and Prizbram's law	1

27	Relative distribution of organisms, Concept of diversity – the Wallacian view	1
28	Assessment of diversity	1
29	Diversity – stability debate, relevance to pest management	1
30	Pest management as applied ecology	1

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1.	Types of distributions of organisms	1
2.	Methods of sampling insects	1
3.	Estimation of densities of insects and understanding the distribution parameters – Measures of central tendencies	1
4.	Poisson Distribution, Negative Binomial Distribution	1
5.	Determination of optimal sample size	1
6.	Learning to fit basic population growth models and testing the goodness of fit	1
7.	Fitting hollings's Disc equation	1
8.	Assessment of prey – predator densities from natural systems and understanding the correlation between the two	2
9.	Assessing and describing niche of some insects of a single guild	1
10.	Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms	2
11.	Calculation of some diversity indices – Shannon's and Avalanche Index and understanding their associations and parameters that affect their values	1
12.	Problem solving in ecology	2
13.	Field visits to understanding different ecosystem and to study insect occurrence in these systems	1

Suggested Readings

- Chapman JL & Reiss MJ. 2006. *Ecology: Principles & Applications*. 2nd Ed. Cambridge Univ. Press, Cambridge.
- Gotelli NJ & Ellison AM. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc., Sunderland, MA.
- Gotelli NJ. 2001. *A Primer of Ecology*. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA.
- Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.
- Krebs CJ. 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 Univ. Press, Princeton.
- Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.
- Real LA & Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.
- Southwood TRE & Henderson PA. 2000. *Ecological Methods*. 3rd Ed. Methuen & Co. Ltd., London.
- Speight MR, Hunt MD & Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.
- Wilson EO & William H Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.
- Wratten SD & Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL, implementing IPM programmes.

Theory:

History and origin, definition and evolution of various related terminologies, Concept of IPM; Economic decision levels of insect pest population, Insect dominance, increase in agriculture pest problem, pest outbreak and factors affecting it; Categories of pest, Tools of pest management and their integration- legislative, cultural, physical and mechanical methods, host plant resistance, biological control, semiochemicals, botanicals and chemical control, insecticide resistance management; sampling, survey, surveillance and forecasting. Controversies, criticism and constraints in IPM. Case studies of successful IPM programmes. Pest control appliances and their maintenance.

Practical:

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Use of pest control appliances and their maintenance.

Lecture schedule--Theory

S.No.	Topic	No. of Lectures
1	IPM- History, origin, definitions and importance.	1
2	IPM -Concept and Economic decision levels ; ETL, EIL & GEP.	2
3	Insect dominance.	1
4	Pest outbreak , causes and factors affecting it.	1
5	Categories of pests.	1
6	Tools of pest management and their integration; cultural control.	1
7	Physical and mechanical control.	2
8	Legislative control.	2
9	Host plant resistance; principles, concept, characterisation and mechanisms and potential in IPM.	2
10	Semiochemicals- pheromones and allelochemicals and their potential in IPM.	1
11	Hormones (IGRs) and their potential in IPM.	1
12	Biological control- definition, techniques, parasitoids and predators; Microbial control- definition, common microbes; advantages and disadvantages of biocontrol.	2
13	Chemical control; classification of insecticides based on mode of entry, action, toxicity and chemical nature; formulations of insecticides.	2
14	Common insecticides and their use- botanicals, chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, novel insecticides, chitin synthesis inhibitors, rodenticides, fumigants;	3
15	Insect attractants, repellents and antifeedents,	1
16	Genetic insect control- gamma radiation and chemosterilants.	1
17	Insecticidal poisoning and antidotes; safe use of insecticides.	1
18	Insecticide resistance management.	1
19	Assessment of insect populations-Sampling techniques.	1
20	Survey, surveillance and forecasting of pest populations.	1
21	Controversies, criticism and constraints in IPM.	1
22	Case studies of successful IPM programmes.	1
23	Pest control appliances and their maintenance.	2

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1	Characterization of agro-ecosystems.	2
2	Sampling methods and factors affecting sampling.	2

3	Population estimation methods.	2
4	Crop loss assessment- direct, indirect, potential, avoidable and unavoidable losses.	2
5	Computation of ETL and EIL.	2
6	Crop modelling.	1
7	Designing and implementing IPM system.	1
8	Use of pest control appliances and their maintenance.	4

Suggested Readings

- Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural entomology*. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management*. 1st Ed., Springer, New York.
- Horowitz AR & Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
- Ignacimuthu SS & Jayaraj S. 2007. *Biotechnology and Insect Pest anagement*. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest anagement*. John Wiley & Sons, New York.
- Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

ENT 521

Classification of Insects

3(2+1)

OBJECTIVE

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects.

Theory:

Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained, Distinguishing characters, general biology, habits and abitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera– Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera, Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera– Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuropterand Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

Lecture schedule---Theory

S.No.	Topic	No. of lectures
1.	Brief evolutionary history of Insects- introduction to phylogeny of insects and major classification of superclass Hexapoda.	2
2.	Distinguishing characters, general biology, habits and habitats of Insect orders and	1

	economically important families contained in them.	
3.	Order Collembola, Protura, Diplura.	1
4.	Order Archaeognatha, Thysanura.	1
5.	Order Odonata, Ephemeroptera.	1
6.	Order Plecoptera, Blattodea,	1
7.	Order Isoptera,	1
8.	Order Mantodea, Grylloblattodea	1
9.	Order Dermaptera, Phasmatodea, Mantophasmatodea	1
10.	Order Orthoptera,	1
11.	Order Embioptera, Zoraptera	1
12.	Order Psocoptera, Phthiraptera	1
13.	Order Thysanoptera	1
14.	Order Hemiptera	3
15.	Order Strepsiptera, Megaloptera	1
16.	Order Raphidioptera, Neuroptera	1
17.	Order Coleoptera	3
18.	Order Mecoptera, Siphonaptera	1
19.	Order Diptera	2
20.	Order Trichoptera	1
21.	Order Lepidoptera	3
22.	Order Hymenoptera	2

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1.	Study of orders of insects and their identification using taxonomic keys.	1
2.	Keying out families of insects of different major Orders: Odonata, Orthoptera	1
3.	Order Blattodea, Mantodea	1
4.	Order Isoptera, Hemiptera	2
5.	Order Thysanoptera, Phthiraptera	1
6.	Order Neuroptera, Coleoptera	2
7.	Order Diptera, Hymenoptera	2
8.	Order Lepidoptera	2
9.	Field visits to collect insects of different orders	4

Suggested Readings

1. Blackwelder RE. 1967. *Taxonomy - A Text and Reference Book*. John Wiley & Sons, New York.
2. Kapoor VC. 1983. *Theory and Practice in Animal Taxonomy*. Oxford & IBH, New Delhi.
3. Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw-Hill, New Delhi.
4. Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman & Hall, London.
5. Ross HH. 1974. *Biological Systematics*. Addison Wesley Publ. Co.
6. Triplehorn CA & Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects*. 7th Ed. Thomson/Brooks/Cole, USA/Australia.

ENT 522

Insect Physiology & Nutrition

3(2+1)

Objective

To impart knowledge to the students on the elementary physiology, nutritional physiology and their application in entomology.

Theory

Scope and importance of insect physiology and nutrition, physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands, thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapauses, Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular micro-organisms and their role in physiology; artificial diets,

Practical

Preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1	Scope and importance of insect physiology and nutrition	2
2	Physiology of digestive systems	2
3	Physiology of circulatory systems	2
4	Physiology of respiratory systems	2
5	Physiology of excretory systems	2
6	Physiology of nervous systems	2
7	Physiology of sensory organs	2
8	Physiology of reproductive systems	3
9	Physiology of musculature	1
10	Physiology of endocrine and exocrine glands	2
11	physiology of integument	1
12	Moulting process in insect cuticle	1
13	Growth, metamorphosis and diapause	1
14	Role of vitamins, proteins, amino acids in Insect nutrition	2
15	Role of carbohydrates, lipids, minerals and other food constituents in Insect nutrition	2
16	Extra and intra-cellular micro-organisms and their role in physiology	2
17	Artificial diet for rearing of different insects	3

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1	Preparation of permanent mounts of internal systems	2
2	Chromatographic analysis of free amino acids of haemolymph	2
3	Determination of chitin in insect cuticle	2
4	Examination of insect haemocytes	2
5	Gel electrophoresis for determination of protein in insect haemolymph	3
6	Preparation of artificial diets of different insects	2
7	Study of food utilization indices	3

Suggested Readings

- Chapman RF.1998. *Insects: Structure and Function*. ELBS Ed., London.
- Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*.Kalyani Publ., New Delhi.
- Kerkut GA & Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.
- Patnaik BD. 2002. *Physiology of Insects*. Dominant, New Delhi.
- Richards OW & Davies RG. 1977. *Imm's General Text Book of Entomology*.10thEd. Vol. 1. *Structure, Physiology and Development*. Chapman & Hall, New York.
- Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.
- Wigglesworth VB.1984. *Insect Physiology*. 8th Ed. Chapman & Hall, New York.

Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India, classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organo- chlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, etc., principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity, Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence, Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide formulations and mixtures; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1	Definition and scope of insecticide toxicology	1
2	History of chemical control	1
3	Pesticide use and pesticide industry in India	1
4	Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature	1
5	Structure and mode of action of organo-chlorines,	1
6	Structure and mode of action of organophosphates	1
7	Structure and mode of action of carbamates	1
8	Structure and mode of action of pyrethroids, tertiary amines	1
9	Structure and mode of action of neonicotinoids, oxadiazines, phenyl pyrozoles	2
10	Structure and mode of action of growth regulators, microbial	2
11	Structure and mode of action of botanicals, new promising compounds	2
12	Principles of toxicology	1
13	Evaluation of insecticide toxicity	1
14	Joint action of insecticides- synergism, potentiation and antagonism	1
15	Factors affecting of insecticides	1
16	Insecticide compatibility, selectivity and phytotoxicity	1
17	Insecticide metabolism	2
18	Pest resistance to insecticides	1
19	Mechanisms and types of resistance	2
20	Insecticide resistance management and pest resurgence	2
21	Insecticide residues, their significance and environmental implications	2
22	Insecticide Act	1
23	Registration and quality control of insecticides	1
24	Safe use of insecticides	1
25	Diagnosis and treatment of insecticide poisoning	1

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1	Insecticide formulations and mixtures	1
2	Quality control of pesticide formulations	1
3	Laboratory and field evaluation of bio-efficacy of insecticides	2
4	Bioassay techniques	2
5	Probit analysis	1
6	Evaluation of insecticide toxicity and joint action	2
7	Toxicity to beneficial insects	1
8	Pesticide appliance	1
9	Working out doses and concentrations of pesticides	2
10	Visit to toxicology laboratories	1
11	Good laboratory practices	2

Suggested Readings

- Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection*. Oxford & IBH, New Delhi.
- Gupta HCL. 1999. *Insecticides: Toxicology and Uses*. Agrotech Publ., Udaipur.
- Ishaaya I & Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action*. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. *Toxicology of Insecticides*. Plenum Press, New York.
- Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. *Insecticides in Agriculture and Environment*. Narosa Publ. House, New Delhi.
- Prakash A & Rao J. 1997. *Botanical Pesticides in Agriculture*. Lewis Publ., New York.

ENT 524**Pests of Field Crops****3(2+1)****Objective**

To familiarize the students about nature of damage and seasonal incidence of insect pests that cause loss to major field crops and their effective management by different methods.

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors, Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.), Insect pests of pulses, tobacco, oilseeds and their management, Insect pests of fibre crops, forages, sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1	Systematic position, identification, distribution, host range, bionomics, nature and extent of damage, seasonal abundance and management of insect- pests of cereals and millets.	5
2	Insect pests of pulses.	3
3	Insect pests of tobacco.	1
4	Insect pests of oilseeds.	4
5	Insect pests of fibre crops.	4
6	Insect pests of forage crops.	1
7	Insect pests of sugarcane.	3
8	Poly phagous pests- grasshopper, locust, termite, white grubs and red hairy caterpillar.	8

9	Non- insect pests and their management- mites, birds, rodents, snails and slugs.	3
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Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1	Field visits, collection and identification of important pests and their natural enemies	6
2	Detection and estimation of infestation and losses in different crops	4
3	Study of life history of important pests	6

Suggested Readings

- Atwal AS, Dhaliwal GS & David BV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publ., 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 & Mathur RP. 1987. *Management of Rodent Pests*. ICAR, New Delhi.
- Saxena RC & Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Jodhpur.

ENT 531

Pests of Horticultural and Plantation Crops

3(2+1)

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops, Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, ber, fig, citrus, aonla, pineapple, apple, peach and other temperate fruits, Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc., Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine etc., Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and non- insect pests.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1.	Pests of mango	2
2.	Pests of guava, banana	2
3.	Pests of jack fruit, papaya, pomegranate	2
4.	Pests of litchi, ber	1
5.	Pests of grapes	2
6.	Pests of fig, aonla	1
7.	Pests of citrus	3
8.	Pests of apple, peach and other temperate fruits	2
9.	Pests of tomato, potato	1
10.	Pests of radish, carrot, beetroot	1

11.	Pests of cole crops	2
12.	Pests of beans	1
13.	Pests of brinjal	1
14.	Pests of okra, drumstick, leafy vegetables	1
15.	Pests of gourds	2
16.	Pests of plantation crops	2
17.	Pests of spices and condiments	1
18.	Pests of beetlevine, ornamental plants, aromatic plants	2
19.	Pests of medicinal plants	1
20.	Pests in polyhouses and protected cultivation	2

Lecture schedule-- Practical

S.No.	Topic	No. of lectures
1.	Identification of important pests and their natural enemies on different crops; study of life history of important insect pests and non- insect pests: Pests of mango, guava, banana, jack fruit, papaya, pomegranate.	1
2.	Pests of litchi, ber, grapes, fig, aonla	1
3.	Pests of citrus	1
4.	Pests of apple, peach and other temperate fruits	1
5.	Pests of tomato, potato, radish, carrot, beetroot	1
6.	Pests of cole crops, beans	1
7.	Pests of brinjal, okra, drumstick, leafy vegetables, gourds	1
8.	Pests of plantation crops, spices, condiments, ornamental plants, aromatic plants	1
9.	Pests of beetlevine, medicinal plants	1
10.	Pests in polyhouses and protected cultivation	1
11.	Collection and study of life history of important insect pests and non- insect pests.	6

Suggested Readings

- Atwal AS & Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management*. Kalyani Publ., New Delhi.
- Butani DK & Jotwani MG. 1984. *Insects and Vegetables*. Periodical Expert Book Agency, New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essential of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Srivastava RP.1997. *Mango Insect Pest Management*. International Book Distr., Dehra Dun.
- Verma LR, Verma AK & Goutham DC. 2004. *Pest Management in Horticulture Crops : Principles and Practices*. Asiatech Publ., New Delhi.

ENT 533

Biological Control of Crop Pests and Weeds

3(2+1)

Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like arasitoids, predators and various entomopathogenic microorganisms.

Theory

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation, Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects, Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation, Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical:

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1.	History, principles and scope of biological control	3
2.	Important groups of parasitoids, predators and pathogens	3
3.	Principles of classical biological control- importation, augmentation and conservation.	2
4.	Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects	3
5.	Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action	6
6.	Biological control of weeds using insects	2
7.	Mass production of quality biocontrol agents- techniques, formulations	3
8.	Economics, field release/ application and evaluation.	2
9.	Successful biological control projects, analysis, trends and future possibilities of biological control.	2
10.	Importation of natural enemies- Quarantine regulations	2
11.	Biotechnology in biological control	2
12.	Semiochemicals in biological control	2

Lecture schedule-- Practical

S.No.	Topic	No.of lectures
1.	Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers.	4
2.	Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds.	2
3.	Field collection of parasitoids and predators	4
4.	Hands-on training in culturing, identification of common insect pathogens	4
5.	Quality control and registration standards for biocontrol agents	2

Suggested Readings

- Burges HD & Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
- De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, New York.
- Dhaliwal GS & Arora R. 2001. *Integrated Pest Management: Concepts and Approaches*. Kalyani Publ., New Delhi.
- Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman & Hall, New York.
- Huffaker CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.
- Ignacimuthu SS & Jayaraj S. 2003. *Biological Control of Insect Pests*. Phoenix Publ., New Delhi.
- Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., NewDelhi.
- Van Driesche & Bellows TS. Jr.1996. *Biological Control*. Chapman & Hall, New York.

ENT 611

Molecular Approaches In Entomological Research

3(3+0)

Objective

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, biotechnology in

sericulture and apiculture.

Theory

Introduction to molecular biology; techniques used in molecular biology, DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi, Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, C_PTi; lectins and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Bt toxin, C_PTi; trypsin inhibitors, lectins and proteases, neuropeptides. Transgenic plants for pest resistance and diseases, Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies, DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Lecture schedule-- Theory

S.No.	Topic	Lectures
1.	Introduction to molecular biology	1
2.	Techniques used in molecular biology	2
3.	DNA and RNA analysis in insects- transcription and translocation mechanisms	2
4.	DNA recombinant technology	3
5.	Identification of genes/nucleotide sequences for characters of interest	2
6.	Genetic improvement of natural enemies	1
7.	Cell lines, genetic engineering in baculoviruses, <i>Bt</i> and entomopathogenic fungi	2
8.	Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, C _P Ti; lectins and proteases.	2
9.	Peptides and neuropeptides, Bt toxin, trypsin inhibitors, lectins and proteases, neuropeptides	1
10.	Transgenic plants for pest resistance and diseases	2
11.	Insect gene transformation	2
12.	Biotechnology in relation to silkworms and honey bees	2
13.	Introduction of lectin genes for pest suppression	1
14.	DNA finger printing for taxonomy and phylogeny	1
15.	Genetic improvement of inebriate tolerance of natural enemies	1
16. 17.	DNA-based diagnostics Insect immune systems in comparison to vertebrates, Molecular basis of metamorphosis	2 2
19.	Sf transgenic technology and implications	1
20.	Molecular biology of baculoviruses	1
21.	Insecticide resistance, Resistance management strategies in transgenic crops.	1

Suggested Readings

- Bhattacharya TK, Kumar P & Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publ., New Delhi.
- Hagedon HH, Hilderbrand JG, Kidwell MG & Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.
- Oakeshott J & Whitten MA.. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.
- Rechcigl JE & Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests*. Lewis Publ., North Carolina.
- Roy U & Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publ., New Delhi.
- Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publ., New Delhi.
- Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publ., New Delhi.

ENT 6 12**Advanced Insect Physiology****3(3+0)****Objective**

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones etc.

Theory

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization, Wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development, physiology of excretion and osmoregulation, water conservation mechanisms, Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms, Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

Lecture schedule-- Theory

S.No.	Topic	No. of lectures
1	Physiology and biochemistry of insect cuticle	2
2	Moulting process of insect cuticle	2
3	Biosynthesis of chitin	1
4	Chitin-protein interactions in various cuticles	1
5	Types of sclerotization	2
6	Digestive enzymes	2
7	Digestive physiology in phytophagous insects	4
8	Digestive physiology in wood boring insects	2
9	Digestive physiology in wool feeding insects	2
10	Efficiency of digestion and absorption	1
11	Role of endosymbionts in insect nutrition	1
12	Nutritional effects on growth and development	2
13	Physiology of excretion and osmoregulation	2
14	Water conservation mechanisms.	2
15	Detailed physiology of nervous system	3
16	Transmission of nerve impulses, neurotransmitters and modulators.	2
17	Production of receptor potentials in different types of sensilla	2
18	Pheromones and other semiochemicals in insect life	3
19	Toxins and defense mechanisms	2
20	Endocrine system and insect hormones	3
21	Physiology of insect growth and development- metamorphosis, polyphenism and diapause.	5
22	Energetics of muscle contractions	2

Suggested Readings

- Kerkut GA & Gilbert LI. 1985. *Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, Oxford, New York.
- Muraleedharan K. 1997. *Recent Advances in Insect Endocrinology*. Assoc. for Advancement of Entomology, Trivandrum, Kerala.

Objective

To acquaint the students with recent concepts of integrated pest management. Surveillance and data base management. Successful national and international case histories of integrated pest management, non conventional tools in pest management.

Theory

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modelling, Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests, Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' real- time situations (IPM modules of important crops), Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Lecture schedule-- Theory

S.No.	Topic	No. of Lectures
1	Principles of sampling and surveillance of pest populations	4
2	Database management and computer programming in pest management.	2
3	Simulation techniques, system analysis and modelling.	
4	Case histories of national and international programmes, their implementation, adoption and criticisms.	3
5	Global trade and risk of invasive pests.	4
6	Genetic engineering and technologies- their progress and limitations in IPM programmes.	5
7	Deployment of benevolent alien genes for pest management- case studies	2
8	Scope and limitations of bio-intensive and ecological based IPM programmes	4
9	Application of IPM to farmers real-time situations (IPM modules of important crops)	6
10	IPM- challenges, needs and future outlook.	2
11	Dynamism of IPM under changing cropping system and climate.	5
12	Insect pest management under protected cultivation.	6
13	Strategies for pesticide resistance management.	3

Suggested Readings

- Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and approaches*. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management*. Springer, Berlin.
- Koul O & Cuperus GW. 2007. *Ecologically Based Integrated Pest Management*. CABI, London.
- Koul O, Dhaliwal GS & Curperus GW. 2004. *Integrated Pest Management-Potential, Constraints and Challenges*. CABI, London.
- Maredia KM, Dakouo D & Mota-Sanchez D. 2003. *Integrated Pest Management in the Global Arena*. CABI, London.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concept in Integrated Pest Management*. Prentice Hall, New Delhi.
- Pedigo RL. 1996. *Entomology and Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.

Objective

To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

Theory

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations, Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices, Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of biocontrol agents, bankable project preparation, Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests; project document, preparation for establishing a viable mass-production unit /insectary.

Lecture schedule-- Theory

S.No.	Topic	Lectures
1.	Scope of classical biological control and augmentative biocontrol	2
2.	Introduction and handling of natural enemies	2
3.	Nutrition of entomophagous insects and their hosts	2
4.	Dynamics of biocontrol agents <i>vis-à-vis</i> target pest populations.	3
5.	Mass culturing techniques	3
6.	Insectary facilities and equipments, basic standards of insectary	3
7.	Viable mass-production unit, designs, precautions, good insectary practices	3
8.	Colonization, techniques of release of natural enemies	2
9.	Recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations	3
10.	Bankable project preparation	2
11.	Scope of genetically engineered microbes and parasitoids in biological control	2
12.	Genetics of ideal traits in biocontrol agents for introgressing and for progeny selections	3
13.	Breeding techniques of biocontrol agents.	2

Lecture schedule-- Practical

S.No.	Topic	Lectures
1.	Mass rearing and release of some commonly occurring indigenous natural enemies	4
2.	Assessment of role of natural enemies in reducing pest populations	2
3.	Testing side effects of pesticides on natural enemies	2
4.	Effect of semiochemicals on natural enemies	2
5.	Breeding of various biocontrol agents	2
6.	Performance of efficiency analysis on target pests	2
7.	Project document preparation for establishing a viable mass-production unit /insectary	2

Suggested Readings

Burges HD & Hussey NW. (Eds.). 1971. *Microbial Control of Insects and Mites*. Academic Press, London.
Coppel HC & James WM. 1977. *Biological Insect Pest Suppression*. Springer Verlag, Berlin.

- De Bach P. 1964. *Biological Control of Insect Pests and Weeds*. Chapman & Hall, London.
- Dhaliwal, GS & Koul O. 2007. *Biopesticides and Pest Management*. Kalyani Publ., New Delhi.
- Gerson H & Smiley RL. 1990. *Acarine Biocontrol Agents– An Illustrated Key and Manual*. Chapman & Hall, New York.
- Huffakar CB & Messenger PS. 1976. *Theory and Practices of Biological Control*. Academic Press, London.

List of Journals

- Agricultural and Forest Entomology*- Royal Entomological Society, UK
- Annual Review of Entomology*- Paloalto, California, USA
- Applied Soil Ecology*- Elsevier Science, Amsterdam, The Netherlands
- Biopesticides International*- Koul Research Foundation, Jalandhar
- Bulletin of Entomological Research*- CAB International, Wallingford, UK
- Bulletin of Grain Technology*- Food Grain Technologist Res. Association of India, Hapur
- Crop Protection*- Elsevier's Science, USA
- Ecological Entomology* -Royal Entomological Society, UK
- Entomologia Experimentalis Applicata*- Kluwer Academic Publishers, The Netherlands
- Entomon*- Association for Advancement of Entomology, Kerala
- Environmental Entomology*- Entomological Society of America, Maryland, USA
- Indian Journal of Applied Entomology*- Entomological Research Association, Udaipur
- Indian Journal of Entomology*- Entomological Society of India, New Delhi
- Indian Journal of Plant Protection*- Plant Protection Society of India, Hyderabad
- Indian Journal of Sericulture*- Central Silk Board, Bangalore
- International Journal of Acarology*- Indira Acarology Publishing House, Minnessota, USA
- International Journal of Pest Management*- Taylor and Francis, UK
- Journal of Acarology*- Acarological Society of India, UAS, Bangalore
- Journal of Apiculture Research*- IBRA, UK
- Journal of Applied Entomology*- Blackwell Science Ltd., Oxford, UK
- Journal of Biocontrol*- Society for Biocontrol Advancement, Bangalore
- Journal of Economic Entomology*- Entomological Society of America, Maryland, USA
- Journal of Entomological Research*- Malhotra Publishing House, New Delhi
- Journal of Insect Behaviour*- Plenum Publishing Corporation, NY, USA
- Journal of Insect Physiology*- Pergamon Press, UK
- Journal of Insect Science*- Indian Society for the Advancement of Insect Science, Ludhiana
- Journal of Invertebrate Pathology*, Elsevier Publ. Corporation, The Netherlands
- Journal of Soil Biology and Ecology*, Indian Society of Soil Biology and Ecology, UAS, Bangalore
- Journal of Stored Products Research*- Elsevier's Science, USA
- Pesticides Research Journal*- Society of Pesticides Science, New Delhi
- Pesticide Science* – Oxford, London
- Pesticide Biochemistry and Physiology*- New York, USA
- Physiological Entomology*- Royal Entomological Society, UK
- Review of Applied Entomology*- CAB International, Wallingford, UK
- Systematic Entomology*- Royal Entomological Society, UK

e-Resources

- <http://www.colostate.edu/Depts/Entomology/>
- <http://www.ent.iastate.edu/list/>
- <http://www.biologybrowser.org/>
- <http://www.teachers.ash.org.au/aussieed/insects.htm>
- <http://entomology.si.edu/>
- <http://www.intute.ac.uk/healthandlifesciences/agriculture/>
- <http://www.agriculture.gov.au/>
- <http://www.gbif.org/>
- <http://www.mosquito.org/>

- <http://www.nysaes.cornell.edu/fst/faculty/acree/pheronet/index.html>
- <http://medent.usyd.edu.au/links/links.htm>
- <http://www.ent.iastate.edu/list/>
- <http://www.ento.csiro.au/index.html>
- <http://www.biocollections.org/lib/listbycat.php?cat=Entomology>
- <http://www.IPMnet.org/DIR/>
- http://www.nhm.ac.uk/hosted_sites/acarology/
- <http://www.agnic.org/>
- <http://ars-genome.cornell.edu/>
- <http://www.tulane.edu/~dmsander/garryfavweb.html>
- <http://www.ufsia.ac.be/Arachnology/Arachnology.html>
- <http://www.ippc.orst.edu/IPMdefinitions/home.html>
- <http://www.ent.iastate.edu/list/>
- <http://www.ippc.orst.edu/cicp/pests/vertpest.htm>
- http://ipmwww.ncsu.edu/cicp/IPMnet_NEWS/archives.html
- <http://nematode.unl.edu/wormsite.htm>
- <http://www.bmckay.com/>
- <http://ace.ace.orst.edu/info/extoxnet/pips/pips.html>
- <http://www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm>
- <http://www.ceris.purdue.edu/npirs/npirs.html>
- <http://www.ces.ncsu.edu/depts/pp/bluemold/>
- <http://www.ipm.ucdavis.edu>
- <http://ippc.orst.edu/pestalert/>
- <http://www.orst.edu/Dept/IPPC/wea/>
- <http://www.barc.usda.gov/psi/bpdl/bpdl.html>
- <http://www.nalusda.gov/bic/BTTOX/bttox.htm>
- <http://www.nysaes.cornell.edu/ent/biocontrol/>
- <http://entweb.clemson.edu/cuentres/>
- <http://www.agr.gov.sk.ca/Docs/crops/cropguide00.asp>
- <http://www.caf.wvu.edu/kearneysville/wvufarm6.html>
- <http://www.chebucto.ns.ca/Environment/NHR/lepidoptera.html>
- <http://nt.ars-grin.gov/fungalDATABASES/databaseframe.cfm>
- <http://www.orst.edu/dept/infonet/>
- <http://www.attra.org/attra-pub/fruitover.html>
- <http://www.ceris.purdue.edu/napis/pests/index.html>
- <http://danpatch.ecn.purdue.edu/~epados/farmstead/pest/src/>
- http://ipmwww.ncsu.edu/current_ipm/otimages.html
- <http://nematode.unl.edu/wormhome.htm>
- <http://www.ipm.ucdavis.edu/>
- <http://hammock.ifas.ufl.edu/en/en.html>
- <http://www.rce.rutgers.edu/weeddocuments/index.htm>
- <http://www.agric.wa.gov.au/ento/allied1.htm>
- <http://biology.anu.edu.au/Groups/MES/vide/refs.htm>
- <http://chrom.tutms.tut.ac.jp/JINNO/PESDATA/00database.html>
- <http://agrolink.moa.my/doi/english/croptech/crop.html>
- <http://nbo.icipe.org/agriculture/stemborers/default.html>
- <http://www.bdt.org.br>
- <http://www.bspp.org.uk/fbpp.htm>
- <http://www.elsevier.com/inca/publications/store/3/5/6/>
- <http://www.hbz-nrw.de/elsevier/00207322/>
- http://ianrhome.uni.edu/distanceEd/entomology/401_801_insectphysio.shtml
- www.entsoc.org
- <http://aprtc.org/>
- <http://www.ipmnet.org/news.html>
- <http://www.pestnet.org/>
- www.fruitfly.org

- www.celera.com
- www.hgsc.bcm.tmc.edu/drosophila
- <http://sdb.bio.purdue.edu/fly/aimain/links>
- <http://flybase.bio.indiana.edu/>
- <http://naasindia.org/journals.htm>

EXTENSION EDUCATION

S. No.	Code	Course Title	Credits
M.Sc.(Ag)			
I Semester			
1	EXT 511* M	Development Perspectives of Extension Education	2+1
2	EXT 512* M	Development Communication and Information Management	2+1
3	EXT 513*	Diffusion and Adoption Of Innovations	2+1
II Semester			
4	EXT 521 M	E-Extension	2+1
5	EXT 522 M	Entrepreneurship Development and Management In Extension	2+1
6	EXT 523 M	Human Resource Development	2+1
7	EXT 524	Participatory Methods For Technology Development and Transfer	2+1
III& IV Semester			
8	EXT 531*	Research Methods In Behavioral Sciences	2+1
9	EXT 532	Visual Communication	2+1
10	EXT 541	Master's Seminar	1
11	EXT 542	Master's Research	15
12	EXT 543	Comprehensive	2
Ph.D.			
I Semester			
1	EXT 611	Advances In Agricultural Extension	2+1
2	EXT 612**	Advances In Training Technology	2+1
II Semester & Onward			
4	EXT 621**	Advanced Design and Techniques In Social Science Research	2+1
5	EXT 622	Advanced Management Techniques	2+1
6	EXT 642	Preliminary	4
7	EXT 641	Doctoral Seminar I & Ii	2
8	EXT 643	Doctoral Research	40
12			

* Core courses for Master's programme; ** Core courses for Doctoral programme
M- Minor for Economics

The following Basic Supporting courses are also recommended for M. Sc. / Ph. D. programmes in other departments of the college

M. Sc.		
STAT 511	Statistical Methods	3(2+1)
STAT 522	Sampling Techniques	3(2+1)
Ph. D.		
STAT 524	Applied Regression Analysis	3(2+1)

M.Sc. (Ag) Programme

EXT 511 Development Perspectives of Extension Education

3(2+1)

Objective

The course is intended to orient the students with the concept of extension education and its importance in Agriculture development and also to expose the students with various rural development programmes aimed at poverty alleviation and to increase employment opportunities and their analysis. Besides, the students will be learning about the new innovations being brought into the Agricultural Extension in India.

Theory

Extension Education – Meaning, objectives, concepts, principles and philosophy, critical analysis of definitions – Extension Education as a Profession – Adult Education and Distance Education. Pioneering Extension efforts and their implications in Indian Agricultural Extension – Analysis of Extension systems of ICAR and SAU – State Departments Extension system and NGOs – Role of Extension in Agricultural University. Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development. Current Approaches in Extension: Decentralized Decision Making, Bottom up Planning, Farming System Approach, Farming Situation Based Extension, Market – Led – Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

Practical

Visit to Gram Panchayat to study on-going Rural Development Programmes, Visit to KVK, NGO and Extension centers of State Agricultural University and State Departments, Bottom up planning, Report preparation and presentations.

Lecture schedule :Theory

S.No.	Topic	No. of lectures
1.	Extension Education – meaning, objectives, concepts	2
2.	Extension Education - principles and philosophy	1
3.	Extension Education – critical analysis of definitions	1
4.	Extension Education as a Profession	1
5.	Adult Education and Distance Education	1
6.	Pioneering Extension efforts and their implications in Indian Agricultural Extension	2
7.	Analysis of Extension systems of ICAR and SAU	1
8.	State Departments Extension system and NGOs	2
9.	Role of Extension in Agricultural University.	1
10.	Poverty Alleviation Programmes – SGSY, SGRY	2
11.	Poverty Alleviation Programmes – PMGSY, DPAP, DDP, CAPART	2
12.	Employment Generation Programmes – NREGP	2
13.	Women Development Programmes – ICDS, MSY, RMK	2
14.	Problems in Rural Development.	2
15.	Current Approaches in Extension	2

16.	Decentralized Decision Making, Bottom up Planning	1
17.	Farming System Approach, Farming Situation Based Extension	2
18.	Market – Led – Extension	2
19.	Farm Field School	1
20.	ATIC	1
21.	Kisan Call Centres, NAIP	1

Lecture schedule :Practical

S.No.	Topic	No. of lectures
1.	Visit to Gram Panchayat to study on-going Rural Development Programmes	2
2.	Visit to KVK	3
3.	Visit to NGO	2
4.	Visit to Extension centers of State Agricultural University	3
5.	Visit to State Departments	3
6.	Bottom up planning	1
7.	Report preparation	1
8.	Report presentations.	1

Suggested Readings

- Chandrakandan KM, Senthil Kumar & Swatilaxmi. PS. 2005. *Extension Education What? And What Not ?* RBSA Publ.
- Gallagher K. 1999. *Farmers Field School (FFS) – A Group Extension Process based on Non-Formal Education Methods*. Global EPM Facility, FAO.
- Ganesan R, Iqbal IM & Anandaraja N. 2003. *Reaching the Unreached: Basics of Extension Education*. Associated Publishing Co.
- Jalihal KA & Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension*. Concept Publ.
- Khan PM. 2002. *Textbook of Extension Education*. Himalaya Publ.
- Ray GL. 2006. *Extension Communication and Management*. Kalyani Publ. Van Den Ban AW & Hawkins HS. 1998. *Agricultural Extension* .2nd Ed. CBS.
- Viswanathan M. 1994. *Women in Agriculture and Rural Development*. Printwell Publ.

EXT 512 Development Communication And Information Management

3(2+1)

Objective

In this course, students will learn about the concept, meaning and process of communication and various methods and modern media of communication. Besides, the students will also learn the information management and journalistic writing of various information materials and also study their readability.

Theory

Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication – Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Key communicators – Meaning, characteristics and their role in development. Media in communication – Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media – Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications. Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Rewriting Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV.

Practical

Writing News for Farm News paper/Magazines. Reporting of Various Extension activities like-Field day, Training, Result Demonstration and farmer' fair etc. Preparing and delivering effective speech. Handling of communication and recording equipments (like-Computer, P.A.System & Camera). Script writing for Radio, T.V. Conducting students' visit to Radio & T.V. station

Lecture schedule :Theory

S. No.	Topic	No. of lectures
1.	Communication process – concept, elements and their characteristics	2
2.	Models and theories of communication	1
3.	Communication skills– fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks	3
4.	Development communication – Barriers in communication	1
5.	Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message.	1
6.	Methods of communication – Meaning and functions, classification	2
7.	Forms of communication – Oral and written communication	1
8.	Non-verbal communication, interpersonal communication, organizational communication. Key communicators	2
9.	Meaning, characteristics and their role in development.	1
10.	Media in communication – Role of mass media in dissemination of farm technology	2
11.	Effect of media mix for Rural People. Modern communication media	2
12.	Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications.	2
13.	Agricultural Journalism as a means of mass communication, Its form and role in rural development	2
14.	Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders	2
15.	Techniques of collection of materials for news stories and feature articles	2
16.	Rewriting Art of clear writing, Readability and comprehension testing procedures	2
17.	Photo journalism, communicating with pictures.	2
18.	Radio and TV Journalism, Techniques of writing scripts for Radio and TV.	2
	Total	32

Lecture schedule :Practical

S. No.	Topic	No. of lectures
1.	Writing News for Farm News paper/Magazines	2
2.	Reporting of Various Extension activities like-Field day, Training, Result Demonstration and farmer' fair etc.	3
3.	Preparing and delivering effective speech.	2
4.	Handling of communication and recording equipments (like-Computer, P.A.System & Camera).	3
5.	Script writing for Radio	2
6.	Script writing for T.V.	2
7.	Conducting students' visit to Radio & T.V. station	2
	Total	16

Suggested Readings

- Dahama OP & Bhatnagar OP. 2005. *Education and Communication for Development*. Oxford & IBH.
- Grover I, Kaushik S, Yadav L & Varma SK. 2002. *Communication and Instructional Technology*. Agrotech Publ. Academy.
- Jana BL & Mitra KP. 2005. *Farm Journalism*. Agrotech Publ. Academy.
- Ray GL. 2006. *Extension Communication and Management*. Kalyani Publ.
- Rayudu CS.2002. *Communication*. Himalaya Publ. House.
- Reddy AA. 1987. *Extension Education*. Sree Lakshmi Press, Bapatla.
- Sandhu AS. 2004. *Textbook on Agricultural Communication Process and Methods*. Oxford & IBH.

EXT 513**Diffusion and Adoption of Innovations****3(2+1)****Objective**

The students will learn how the agricultural innovations spread among the farmers in the society by getting into the insights of diffusion concept and adoption process, stages of adoption and innovation decision process, adopter categories and their characteristics, opinion leaders and their characteristics, attributes of innovations, and factors influencing adoption. In addition, the students would be learning various concepts related to diffusion and adoption of innovations.

Theory

Diffusion – concept and meaning, elements; traditions of research on diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice. The adoption process- concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation. Adopter categories – Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption. Diffusion effect and concept of over adoption, opinion leadership- measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation-Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision – making.

Practical

Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology, study of attributes of current farm technologies, Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology, study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

Suggested Readings**Lecture schedule :Theory**

S. No.	Topic	No. of lectures
1.	Diffusion – concept and meaning, elements, traditions of research on diffusion	2
2.	The generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice.	2
3.	The adoption process- concept and stages, dynamic nature of stages, covert and overt processes at stages	3
4.	The innovation-decision process – a critical appraisal of the new formulation.	2
5.	Adopter categories – Innovativeness and adopter categories	1
6.	Adopter categories as ideal types, characteristics of adopter categories	2
7.	Perceived attributes of Innovation and their rate of adoption	2
8.	Factors influencing rate of adoption.	2
9.	Diffusion effect and concept of over adoption	2
10.	Opinion leadership- measurement and characteristics of opinion leaders	2
11.	Monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations	3
12.	Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions	3
13.	Consequences of Innovation-Decisions	2
14.	Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences	2
15.	Decision making – meaning, theories, process, steps, factors influencing decision – making.	2

Lecture schedule :Practical

S. No.	Topic	No. of lectures
1.	Case studies in individual and community adoption process	2
2.	Content analysis of adoption studies	2

3.	Identification of adopter categories on a selected technology	2
4.	Study of attributes of current farm technologies	2
5.	Identification of opinion leaders	2
6.	Sources of information at different stages of adoption on a selected technology	2
7.	Study of factors increasing or retarding the rate of adoption	2
8.	Presentation of reports on adoption and diffusion of innovations.	2

Suggested Readings

Dasgupta. 1989. *Diffusion Agricultural Innovations in Village India*. Wiley Eastern.

Jalihah KA & Veerabhadraiah V. 2007. *Fundamentals of Extension Education and Management in Extension*. Concept Publ. Co.

Ray GL. 2005. *Extension Communication and Management*. Kalyani Publ.

Reddy AA. 1987. *Extension Education*. Sree Lakshmi Press, Bapatla.

Rogers EM. 2003. *Diffusion of Innovations*. 5th Ed. The Free Press, NewYork.

EXT 521

e- Extension

3(2+1)

Objective

Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. Reaching the unreached.

Theory

ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities. ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc. Community Radio, Web, Tele, and Video conferencing. Computer Aided Extension. Knowledge management, Information kiosks, Multimedia. Online, Offline Extension. Tools-Mobile technologies, e-learning concepts. ICT Extension approaches-pre-requisites, information and science needs of farming community. Need integration. Human resource information. Intermediaries. Basic e-extension training issues. ICT enabled extension pluralism. Emerging issues in ICT.

Practical

AgriL.content analysis of ICT Projects. Handling of ICT tools. Designing extension content. Online extension service. Project work on ICT enabled extension. Creation of extension blogs. Visit to ICT extension projects.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
3	Advantages, limitations and opportunities.	1
6	ICT use in field of extension	2
7	Expert systems on selected crops and enterprises	1
8	Self learning CDs on package of practices, diseases and pest management	2
9	Agricultural web sites and portals related crop production and marketing etc	2
10	Community Radio, Web, Tele, and Video conferencing.	2
11	Computer Aided Extension	2
12	Knowledge management	1
13	Information kiosks,	2
14	Multimedia.	1
15	Online, Offline Extension. Tools	1
16	Mobile technologies	1
17	e-learning concepts.	1
18	ICT Extension approaches-pre-requisites,	1
19	information and science needs of farming community.	1
20	Need integration	1
21	Human resource information Intermediaries	1

22	Basic e-extension training issues.	1
23	ICT enabled extension pluralism.	1
24	Emerging issues in ICT	1

Lecture schedule- Practical

S. No.	Topic	No. of lectures
1	Agril. content analysis of ICT Projects.	2
2	Handling of ICT tools.	2
3	Designing extension content.	2
4	Online extension service.	2
5	Project work on ICT enabled extension.	3
6	Creation of extension blogs.	2
7	Visit to ICT extension projects	3

Suggested Readings

- Batnakar S & Schware R. 2000. *Information and Communication Technology in Development- Cases from India*. Sage Publ.
- Meera SN. 2008. *ICTs in Agricultural Extension: Tactical to Practical*. Ganga-Kaveri Publ. House. JangamWadiMath, Varanasi.
- Willem Zip. 1994. *Improving the Transfer and Use of Agricultural Information - A Guide to Information Technology*. The World Bank, Washington.

EXT 522 Entrepreneurship Development and Management in Extension

3(2+1)

Objective

The first part of the course is intended to provide overall picture of planning and development of enterprises for extending sustainable livelihoods for rural people. The second part of the course is structured to help the students to gain knowledge and skills in different concepts and techniques of management in extension organizations.

Theory

Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development. Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs – Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise – Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects. Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective. Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations. Coordination – Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization. Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods. Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles. Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication. Managing work motivation – Concept, Motivation and Performance, Approaches to motivation.

Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision. Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

Practical

Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal -Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions-Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Lecture schedule- Theory

S.No.	Topic	No. of lectures
1.	Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development.	2
2.	Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods.	1
3.	Traits of entrepreneurs – Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing	2
4.	Types of Entrepreneurs. Stages of establishing enterprise – Identification of sound enterprise	2
5.	Steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements.	2
6.	Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects.	2
7.	Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager.	2
8.	Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective.	2
9.	Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions.	2
10.	Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations.	2
11.	Coordination – Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization.	1
12.	Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods.	2
13.	Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction.	2
14.	Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles.	2
15.	Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication.	2
16.	Managing work motivation – Concept, Motivation and Performance, Approaches to motivation. Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision.	2
17.	Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.	2

Lecture schedule- Practical

S.No.	Topic	No. of lectures
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1.	Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs	2
2.	Development of Project Proposal	2
3.	Case Studies of Success / Failure enterprises-Exercise on Market Survey	2
4.	Field visit to Financial institutions-Simulated exercise to understand management process	2
5.	Field visit to extension organizations to understand the functions of management	2
6.	Group exercise on development of short term and long term plan	2
7.	Simulated exercise on techniques of decision making	2
8.	Designing organizational structure -Group activity on leadership development skills.	2

Suggested Readings

- Gupta CB. 2001. *Management Theory and Practice*. Sultan Chand & Sons.
Indu Grover. 2008. *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
Khanka SS. 1999. *Entrepreneurial Development*. S. Chand & Co.
Singh D. 1995. *Effective Managerial Leadership*. Deep & Deep Publ.
Tripathi PC & Reddy PN. 1991. *Principles of Management*. Tata McGraw Hill.
Vasanta Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.

EXT 523

Human Resource Development

3(2+1)

Objective

To orient the students about key concepts importance, scope & conceptual frame work, growth & development of Human Resource Development, Subsystems of Human Resource Development for extension organization and process of HRD.

Theory

Human Resource Development – Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; HRD Interventions – Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment ; Motivation productivity -job description – analysis and evaluation; Performance Appraisal. Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception ; Stress and coping mechanisms; Inter-Personal Process, Helping Process – communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building – Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager – Responsibility of Professional Manager; Managerial skills and Soft Skills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics : Leadership styles – Group dynamics. Training – Meaning, determining training need and development strategies – Training types, models, methods and evaluation; Facilities for training – Trainers training – techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate – organizing for HRD – emerging trends and Prospective.

Practical

Visit to different training organizations to review ongoing activities & facilities; Analysis of Training methods followed by training institutions for farmers and extension workers Studies on evaluation of training programmes; Study of HRD in organization in terms of performance, organizational development, employees welfare and improving quality of work life and human resource information, Presentation of reports.

Lecture schedule- Theory

S. No.	Topic	No. of lectures
1.	Human Resource Development – Definition and Meaning	1
2.	Importance, Scope and Need for HRD	1
3.	Conceptual frame work, inter disciplinary approach, function systems of HRD	1

4.	Case studies in HRD	1
5.	HRD Interventions – Different Experiences of HRD	1
6.	Selection, Development & Growth for HRD	1
7.	Selection, Recruitment for HRD, Induction Staff Training and Development for HRD	1
8.	Career planning for HRD	1
9.	Social and Organizational Culture for HRD	1
10.	Indian environment perspective on cultural process and social structure, society in transition for HRD	1
11.	Organizational and Managerial values and ethics for HRD	1
12.	Organizational commitment for HRD	1
13.	Motivation productivity and job description for HRD	1
14.	Analysis and evaluation- Performance Appraisal for HRD	1
15.	Human Resource management- definition and meaning	1
16.	Collective bargaining and Negotiation skills	1
17.	Human Resource Accounting (HRA): What is HRA? Why HRA?	1
18.	Information Management for HRA and Measurement in HRA	1
19.	Intra personal processes: Collective behaviour, learning, and perception	1
20.	Stress and coping mechanisms	1
21.	Inter-Personal Process, Helping Process ,communication process, Feedback and interpersonal styles	1
22.	Group & Intergroup process: group information and group processes	1
23.	Organizational communication, Team building Process and functioning	1
24.	Conflict management, Collaboration and Competition	1
25.	HRD & Supervisors: Task Analysis	1
26.	Capacity Building – Counseling and Mentoring	1
27.	Role of a Professional Manager: Task of Professional Manager, Responsibility of Professional Manager	1
28.	Managerial skills and Soft Skills required for Extension workers	1
29.	Decision Making: Decision Making models	1
30.	Management by Objectives	1
31.	Behavioural Dynamics :Leadership styles and Group dynamics	1
32.	Training – Meaning, determining training need and development strategies	1
33.	Training types and models of trainings	1
34.	Methods of trainings	1
35.	Evaluation of trainings and Facilities for training (physical facilities)	1
36.	Trainers training – techniques for trainees participation	1
37.	Research studies in training for extension personnel	1
38.	Main issues in HRD, HRD culture and HRD climate, organizing training for HRD , emerging trends and Prospective for HRD	1

Lecture schedule- Practical

S. No.	Topic	No. of lectures
1.	Visit to different training organizations and to review on going activities & facilities	4
2.	Analysis of Training methods followed by training institutions for farmers and extension workers	4
3.	Studies on evaluation of training programmes organized by training institutions for farmers and extension workers	2
4.	Study of HRD in organization in terms of performance	2
5.	Organizational development, employees welfare and improving quality of work life	2
6.	Study of HRD information and presentation of reports	2

Suggested Readings

Agochiya D. 2002. *Every Trainer's Handbook*. Sage Publ.

David Gross. 1997. *Human Resource Management - The Basics*. TR Publ.

- Davis Keth & Newston W John 1989. *Human Behaviour at Work*. 8th Ed. McGraw-Hill.
- Hersey Paul & Balanchard H Kenneth. 1992. *Management of Organizational Behaviour Utilizing Human Resource*. 5th Ed. Prentice-Hall of India.
- Knoontz Harold & Weihhrich Heinz 1990. *Essentials of Management*. 5th Ed. McGraw-Hill.
- Lynton RP & Pareek U. 1993. *Training for Development*. DB. Taraporewale Sons & Co.
- Punna Rao P & Sudarshan Reddy M. 2001. *Human Resource Development Mechanisms for Extension Organization*. Kalyani Publ.
- Rao TV. 2003. *Readings in Human Resource Development*. Oxford Publ. Co.
- Silberman Mel. 1995. *Active Training*. Press Johnston Publ. Co., New Delhi.
- Singh RP. 2000. *Management of Training Programmes*. Anmol Publ.
- Subba Rao P. 2005. *Management & Organizational Behaviour*. Himalaya Publ. House.
- Sundaram RM, Gupta V, George SS. 2006. *Case Studies in Human Resource Management*. ICFAI, Hyderabad.
- Tripati & Reddy. 2004. *Principles of Management*. Tata McGraw-Hill.
- Wayne MR & Robert MN. 2005. *Human Resource Management*. International Ed. Pearson Prentice Hall.

EXT 524 Participatory Methods for Technology Development and Transfer 3(2+1)

Objective

This course is intended to orient the students with the key concepts, principles process of different participatory approaches for technology development and transfer and also to expose the students with various participatory tools and techniques like space related, time related, relation oriented methods. Besides the students will be learning the preparation of action plans participatory monitoring and evaluation.

Theory

Participatory extension – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models. Participatory tools and techniques. Space Related Methods : village map (social & resource), mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods : cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis. Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical

Simulated exercises on space related methods, time related method and relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

Lecture schedule :Theory

S. No.	Topic	No. of lectures
1.	Participatory extension – Importance, key features	1
2.	Principles and process of participatory approaches	2
3.	Different participatory approaches (RRA,PRA, PLA) and successful models.	3
4.	Different participatory approaches (AEA, PALM, PAR,) and successful models.	3
5.	Different participatory approaches (PAME, ESRE, FPR) and successful models.	3
6.	Participatory tools and techniques. Space Related Methods : village map(social & resource), mobility services and opportunities map and transect.	4
7.	Participatory tools and techniques. Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map.	4
8.	Participatory tools and techniques. Relation oriented methods : cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis.	4
9.	Preparation of action plans, concept and action plan preparation.	2
10.	Participatory technology development and dissemination.	2
11.	Participatory planning and management, phases and steps in planning and implementation aspects.	2

12.	Process monitoring, participatory evaluation.	2
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Lecture schedule : Practical

S.No.	Topic	No. of lectures
1.	Simulated exercises on village map(social & resource)	1
2.	Simulated exercises on mobility services	1
3.	Simulated exercises on opportunities map	1
4.	Simulated exercises on transect walk	1
5.	Simulated exercises on time line	1
6.	Simulated exercises on trend analysis	1
7.	Simulated exercises on seasonal diagram	1
8.	Simulated exercises on Daily activity schedule	1
9.	Simulated exercises on dream map	1
10.	Simulated exercises on cause and effect diagram (problem tree)	1
11.	Simulated exercises on impact – diagram	1
12.	Simulated exercises on well being ranking method	1
13.	Simulated exercises on Venn diagram	1
14.	Simulated exercises on matrix ranking	1
15.	Simulated exercises on livelihood analysis	1
16.	Preparation of action plans	1
17.	Participatory monitoring of developmental programmes	1
18.	participatory evaluation of developmental programmes	1

Suggested Readings

Adhikary. 2006. *Participatory Planning and Project Management in Extension Science*. Agrotech Publ. Academy.
Mukharjee N. 2002. *Participatory Learning and Action*. Concept Publ. Co.
Singh BK. 2008. *PRA/PLA and Participatory Training*. Adhyayan Publ. & Distr.
Somesh Kumar. 2002. *Methods for Community Participation*. Vistaar Publ.

EXT 531 Research Methods In Behavioural Science 3(2+1)

Objective

This course is designed with a view to provide knowledge and skills in methods of behavioural sciences research and student will learn the appropriate statistics for data analysis.

Theory

Research – Meaning, importance, characteristics. Behavioural sciences research – Meaning, concept and problems in behavioural sciences research. Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Review of literature – Need, Search Procedure, Sources of literature, Planning the review work. Research problem – Selection and Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem. Objectives – Meaning, types and criteria for judging the objectives. Concept and Construct – Meaning, role of concepts in research and Conceptual frame work development in research. Variable – Meaning, types and their role in research. Definition – Meaning, characteristics of workable definitions, types and their role in research. Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement – Meaning, postulates and levels of measurement, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning and methods of testing. Reliability – Meaning and methods of testing. Sampling – Universe, Sample and Sampling-Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors – Methods of elimination and minimizing, Maximinon Principle, Sampling – Types of sampling and sampling procedures. Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each

design. Experimental design – Advantages and limitations. Data Collection devices - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations. Check lists – Meaning, steps in construction, advantages and limitations in its use. Rating scales – Meaning, types, limits in construction, advantages and limitations in its use. Observation – Meaning, types, tips in observation, advantages and limitations in its use. Case studies – Meaning, types, steps in conducting, advantages and limitations in its use. Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations. Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

Practical

Selection and formulation of research problem - Formulation of objectives and hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-Development of data collection devices.-Testing the validity and reliability of the data collection instruments.- Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research. Writing report, Writing of thesis and research articles-Presentation of reports.

Lecture schedule :Theory

S.No.	Topic	No. of lectures
1.	Research – Meaning, importance, characteristics.	1
2.	Behavioural sciences research – Meaning, concept and problems in behavioural sciences research.	1
3.	Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study.	2
4.	Review of literature – Need, Search Procedure, Sources of literature, Planning the review work.	1
5.	Research problem – Selection and Formulation of research problem and guiding principles in the choice of research problem	1
6.	Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem.	1
7.	Objectives – Meaning, types and criteria for judging the objectives.	1
8.	Concept and Construct – Meaning, role of concepts in research and Conceptual frame work development in research.	1
9.	Variable – Meaning, types and their role in research. Definition – Meaning, characteristics of workable definitions, types and their role in research.	2
10.	Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis.	2
11.	Measurement – Meaning, postulates and levels of measurement, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research.	2
12.	Validity – Meaning and methods of testing. Reliability – Meaning and methods of testing.	1
13.	Sampling – Universe, Sample and Sampling-Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors	1
14.	Methods of elimination and minimizing, Maximinon Principle, Sampling – Types of sampling and sampling procedures.	2
15.	Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each design. Experimental design – Advantages and limitations.	2
16.	Data Collection devices - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations.	2

17.	Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use.	1
18.	Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations.	1
19.	Check lists – Meaning, steps in construction, advantages and limitations in its use.	1
20.	Rating scales – Meaning, types, limits in construction, advantages and limitations in its use.	1
21.	Observation – Meaning, types, tips in observation, advantages and limitations in its use.	1
22.	Case studies – Meaning, types, steps in conducting, advantages and limitations in its use.	1
23.	Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations.	1
24.	Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, choosing appropriate statistics for data analysis based on the level of measurement of variables.	1
25.	Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.	1

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1.	Selection and formulation of research problem - Formulation of objectives and hypothesis	2
2.	Selection of variables based on objectives-Developing the conceptual framework of research.	2
3.	Operationally defining the selected variables-Development of data collection devices.- Testing the validity	2
4.	Reliability of the data collection instruments.- Pre-testing of the data collection instrument-	2
5.	Techniques of interviewing and collection of data using the data collection instruments-Data processing, coding, tabulation and analysis.	2
6.	Formulation of secondary tables based on objectives of research.	2
7.	Writing report, Writing of thesis and research articles	2
8.	Presentation of reports.	2

Suggested Readings

- Chandrakandan K, Venkatapirabu J, Sekar V & Anand Kumar V. 2000. *Tests and Measurements in Social Research*. APH Publ.
- Kerlinger FN. 1973. *Foundations of Behavioural Research*. Holt Rhinehart.
- Kothari CR.1984. *Research Methodology, Methods and Techniques*. Chaitanya Publ. House.
- Krishnaswami OR & Ranganatham M. 2005. *Methodology of Research in Social Sciences*. Himalaya Publ. House.
- Mulay S & Sabaratnam VE.1983. *Research Methods in Extension Education*. Manasavan.
- Ranjit Kumar. 1999. *Research Methodology - A Step by Step Guide for Beginners*. Sage Publ.
- Ray GL & Sagar Mondal. 1999. *Research methods in Social Sciences and Extension Education*. Naya Prokash.
- Wilkinson TS & Bhandarkar PC.1993. *Methodology and Techniques of Social Research*. Himalaya Publ. Home.

EXT 532

Visual Communication

3(2+1)

Objective

This course is intended to give a clear perspective about the importance of visuals and graphics in communication. The course starts with the delineating about the characteristics of visuals and graphics followed by its main functions, theories of visual perception and its classification and selection. Further, the course deals with the designing the message, graphic formats and devices and presentation of data. It makes the students to understand, prepare and present the scientific data effectively by using low cost visuals. The course also exposes the students to various

Digitized video material in multimedia and also enable to design visuals for print, TV and know-how about scanning of visuals.

Theory

Role of visuals & graphics in Communication. Characteristics of visuals & graphics. Functions of visuals and graphics. Theories of visual perception. Classification and selection of visuals. Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and production of low cost visuals. Photographs- reprographic visuals. PC based visuals. Digitized video material in multimedia production. Designing visuals for print and TV and video. Pre-testing and evaluation of visuals. Scanning of visuals.

Practicals

Preparation of low cost projected and Non-Projected visuals. Designing and layout of charts, posters, flash cards etc. Power point presentations. Generating computer aided presentation graphics. Scanning and evaluation of visuals.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1.	Role of visuals & graphics in Communication.	2
2.	Characteristics of visuals & graphics.	2
3.	Functions of visuals and graphics.	2
4.	Theories of visual perception.	2
5.	Classification and selection of visuals.	2
6.	Designing message for visuals.	2
7.	Graphic formats and devices.	2
8.	Presentation of Scientific data.	2
9.	Principles and production of low cost visuals.	2
10.	Photographs- reprographic visuals.	2
11.	PC based visuals.	2
12.	Digitized video material in multimedia production.	2
13.	Designing visuals for print and TV and video.	2
14.	Pre-testing and evaluation of visuals.	4
15.	Scanning of visuals.	2

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1.	Preparation of low cost projected and Non-Projected visuals.	4
2.	Designing and layout of charts, posters, flash cards etc.	3
3.	Power point presentations.	3
4.	Generating computer aided presentation graphics.	3
5.	Scanning and evaluation of visuals.	3

Suggested Readings

Bhatia A. 2005. *Visual Communication*. Rajat Publications, New Delhi.

Edgar Dale 1970. *Audio Visual methods in Teaching*. Holt, Rinehart & Winston.

James WB, Richard BL, Fried F Harclerod. 1952. *A.V. Instructional Material & Methods*. Mc.Graw Hill.

Reddy YN. 1998. *Audio Visual Aids in Teaching, Training and Extension*. Haritha Publ. House, Hyderabad.

Ph.D. Programme

EXT 611

Advances in Agricultural Extension

3(2+1)

Objective

By the End of the course student will be able to-- Critically analyze different Agricultural Extension approaches. Understand Agricultural Knowledge Information System (AKISs) ITK. Understand Advances in Extension - Cyber extension, ICT enabled extension services; Market Led Extension, Public Private Partnership, Mainstreaming gender in extension organizational Innovations. Visualize implications of WTO - AOA and develop extension strategies.

Understand extension reforms and Farmer Field Schools Decentralized Decision Making, bottom up planning, ATMA, FSBE & CIGs etc., ATIC, IVLP & Kisan Call Centres.

Theory

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS. Cyber Extension - Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market – Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder’s analysis in Extension. Main streaming gender in Extension - Issues and Prospects. Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension. Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

Practical

Analysis of ITK systems, cases on integration of ITK and formal research system, Analysis of cases on cyber extension and privatization of extension. Analysis of ATMA and SREP. Practicing bottom up planning. Visit to Public-Private -Farmer partnership. Learning from Food and Nutritional Security and bio-diversity Projects and Programmes.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1.	Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension	1
2.	Importance and relevance of indigenous knowledge system, identification and documentation of ITK	1
3.	Integration of ITK system in research formulation	1
4.	Concept of Agricultural Knowledge and Information System	1
5.	Training of Stakeholders of AKIS	1
6.	Cyber Extension - Concept of cyber extension	2
7.	National and international cases of extension projects using ICT and their impact of agricultural extension	2
8.	Alternative methods of financing agricultural extension - Scope, limitations and experience and cases	2
9.	Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc.	2
10.	Market – Led Extension, Farmer - Led Extension	2
11.	Concept of Farm Field School, Farm School	1
12.	Public - Private Partnership: Meaning, Models, Identification of various areas for partnership	2
13.	Stakeholder’s analysis in Extension. Main streaming gender in Extension - Issues and Prospects	2
14.	Implications of WTO - AOA for extension services	1
15.	Re-orientation of extension services for agri-business and marketing activities	2
16.	GOI-NGO collaboration to improve efficiency of extension.	2
17.	Extension and contemporary issues	2
18.	Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs).	1
19.	Extension Reforms in India - Decentralized decision making, Bottom up planning	1
20.	Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups	2

21.	Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres	1

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1.	Analysis of ITK systems	2
2.	Cases on integration of ITK and formal research system	2
3.	Analysis of cases on cyber extension and privatization of extension	3
4.	Analysis of ATMA and SREP	2
5.	Practicing bottom up planning	2
6.	Visit to Public-Private -Farmer partnership	2
7.	Learning from Food and Nutritional Security and bio-diversity Projects and Programmes	3

Suggested Readings

- Bagchi J. 2007. *Agriculture and WTO Opportunity for India*. Sanskruti.
 Chambers R, Pacy A & Thrupp LA. 1989. *Farmers First*. Intermediate Technology Publ.
 Crouch BR & Chamala S. 1981. *Extension Education and Rural Development*. Macmillan.
 John KC, Sharma DK, Rajan CS & Singh C. 1997. *Farmers Participation in Agricultural Research and Extension Systems*. MANAGE, Concept Publ. Co.
 Khan PM. 2002. *Text Book of Extension Education*. Himanshu Publ.
 Narasaiah ML. 2005. *Agricultural Development and World Trade Organization*. Discovery Publ.
 Talwar S. 2007. *WTO Intellectual Property Rights*. Serials Publ. Van den Ban BW & Hawkins BS. 1998. *Agricultural Extension*. S.K. Jain Publ.
 Venkaiah S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

EXT 612

Advances In Training Technology

3(2+1)

Objective

By the end of the Course student will be able to--Plan and design a training programme. Plan & Develop effective training sessions. Manage difficult situations while organizing training programmes. Use different advanced participatory training methods.

Theory

Paradigm shift in training - learning scenario, Training Approaches - Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, Course Objective, content and methods. Designing an effective training session - the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees). Recent Training Techniques for understanding and facilitation team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training, Psychological instruments as training tools: TAT, Inventories, Cases, etc. Participatory Training Techniques - Lecture, Brainstorming, Group discussion and Training Games. Role Play, Psycho-drama, Coaching, Counseling, etc., Trainer's roles and dilemmas, Factors Effecting Training Effectiveness and Training Evaluation.

Practical

Techniques of participatory training need assessment. Formulation of Course Objective, design of training programmes. Simulation exercises. Participatory training methods - Role Play & Brainstorming, Group discussion and Counseling and Conducting experiential learning sessions. Training evaluation - Techniques of Knowledge, Skill & Attitude evaluation. Visit to training institutions and study of training technologies followed.

Lecture schedule : Theory

S.No.	Topic	No. of lectures
1.	Paradigm shift in training - learning scenario	1
2.	Training Approaches -Experiential learning - laboratory - organization development (system) approaches	2
3.	Training Design, Designing an effective training programme	2
4.	Harmonizing training needs	2

5.	Course Objective, of training.	1
6.	Content and methods of training	1
7.	Designing an effective training session - the semantics involved	2
8.	Designing experiential training sessions	2
9.	Simulation exercises and openness in training transaction	2
10.	Managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees)	1
11.	Recent Training Techniques for understanding and facilitation team Building	1
12.	Group dynamics	1
13.	Motivation and empowerment	1
14.	Laboratory methods: micro-lab process work and sensitivity training	1
15.	Psychological instruments as training tools	1
16.	TAT, Inventories, Cases	1
17.	Participatory Training Techniques	2
18.	Lecture and Brainstorming methods of training	1
19.	Group discussion and Training Games methods of training	1
20.	Role Play and Psycho-drama method of training	2
21.	Coaching and Counseling	1
22.	Trainer's roles and dilemmas	1
23.	Factors Effecting Training Effectiveness	2
24.	Training Evaluation	2

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1.	Techniques of participatory training need assessment	2
2.	Formulation of Course Objective	1
3.	Design of training programmes	1
4.	Simulation exercises	1
5.	Participatory training methods - Role Play & Brainstorming	3
6.	Group discussion and Counseling	1
7.	Conducting experiential learning sessions.	1
8.	Training evaluation - Techniques of Knowledge, Skill & Attitude determination	3
9.	Visit to training institutions and study of training technologies	3

Suggested Readings

- Agochiya D. 2002. *Every Trainer's Handbook*. Sage Publ.
 Alan B & Calardy 2004. *Five Case Studies in Management Training*. Jaico Publ.
 Kumar A. 2000. *Management Training Process*. Anmol Publ.
 Leslie Rae. 1998. *Techniques of Training*. Jaico Publ.
 Lynton RP & Pareek U. 1999. *Training for Development*. 2nd Ed. Vistar Publ.
 Reid MA. 1997. *Training Interventions, Managing Employee Development*. Jaico. Publ.
 Samanta RK. 1993. *Training Methods for Management and Development*. M.D. Publ.
 Sethy ED. 2003. *A Practical Hand Book on Training*. Anmol Publ.

EXT 621 Advanced Designs and Techniques in Social Science Research

3(2+1)

Objective

By the End of the course student will be able to-- Develop & Standardize Attitude scale using different techniques of attitude scale construction. Develop skills for using Projected & Semi- Projected Techniques, in Extension Research.

Theory

Scaling technique - meaning, types, principles, steps and quality, techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive Intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Reliability and Validity of Scales. Sociometrics, content analysis, case studies, Semantic differential technique. Projective and Semi projective techniques, Critical incident techniques. Knowledge scale measurement. Participatory tools and techniques in behaviour Research - Data collection and Evaluation. Impact analysis.

Practical

Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques. Content analysis, case studies. Practicing participatory tools and techniques. Review of previous studies.

Lecture schedule : Theory

S.No.	Topic	No. of lectures
1.	Scaling technique - meaning, types, principles	2
2.	Scaling technique - steps and quality	2
3.	Techniques of attitude scale construction	2
4.	Paired comparison	2
5.	Equal appearing intervals	2
6.	Successive Intervals	2
7.	Summated ratings	2
8.	Scalogram analysis, Scale discrimination technique	2
9.	Reliability and Validity of Scales.	2
10.	Sociometrics, content analysis	2
11.	Case studies, Semantic differential technique.	2
12.	Projective and Semi projective techniques, Critical incident techniques.	2
13.	Knowledge scale measurement.	1
14.	Participatory tools and techniques in behaviour	3
15.	Research - Data collection and Evaluation.	2
16.	Impact analysis.	2

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1.	Practice in constructing a scale and use of scale in various situations.	3
2.	Reliability and validity of the scales developed	2
3.	Application of Semi Projective and Projective techniques.	3
4.	Content analysis, case studies.	2
5.	Practicing participatory tools and techniques.	3
6.	Review of previous studies.	3

Suggested Readings

- Burns RB. 2000. *Introduction to Research Methods*. Sage Publ.
- Chandrakandan K & Karthikeyan C. 2004. *Behavioral Research Methodology*. Classical Publ.
- Daivadeenam P. 2002. *Research Methodology in Extension Education*. Agro-Tech Publ. Academy.
- Kerlinger N Fred. 2002. *Foundations of Behavioural Research*. Surjeet Publ.
- Kothari CR. 2000. *Research Methodology Methods & Techniques*. 2nd Ed. Wishwa Prakasham.
- Ray GL & Mondal S. 1999. *Research Methods in Social Science and Extension Education*. Naya Prokash.
- Roger L & Domino WSK. 1980. *Research Methods*. Prentice Hall.
- Sadhu AM & Singh A. 2003 *Research Methodology in Social Science*. Himalaya Publ. House.
- Sarantakos S. 1998. *Social Research*. 2nd Ed. Macmillan.
- Sinha SC & Dhiman AK. 2002. *Research Methodology*. ESS Publ.
- Verma RK & Verma G. 2002. *Research Methodology*. Commonwealth Publ.
- Walizer MH & Panl L. 2002. *Research Methods & Analysis; Searching for Relationships*. Wiemil Harper & Row.
- Wilkinson TS & Bhandarkar PL. 2002. *Methodology and Techniques of Social Research*. Himalaya Publ. House.

EXT 622**Advanced Management Techniques****3(2+1)****Objective**

Develop understanding on concept of MIS, its scope in Agriculture Extension Organization. Understand, Develop and Evaluate the MBO System. To cope up with stress, Resolve conflicts and develop effective inter personal communication skills using Transactional analysis. To plan & use, DSS, AI, ES, PERT, CPM

Theory

Management Information System (MIS): Basic concepts, types of information needed at various levels, design of MIS in an agricultural extension organization. Scope for computerization, system alternatives and Evaluation. Implementation, operation and maintenance of the system. Management by Course Objective (MBO): Elements of the MBO system. The Process of MBO. Making MBO effective. Evaluation of the MBO system - strengths and weaknesses. Transactional Analysis (TA): Ego states, transactions, inter relationships, strokes, stamps. Managing Organizational Stress: Sources of stress in organization, effect of stress. Coping mechanisms and managing stress, Stress management, Team Building Process: Types of teams. Steps in teamwork, Facilitators and barriers to effective relationships, nature of prejudice, tips in reducing interpersonal conflicts, inter-group conflict, resolving techniques. Conflict management, tips in reducing interpersonal conflicts. Decision Support Systems (DSSs): Basic information about Artificial Intelligence (AI) Expert System (ESs), their future applications in extension system. Forecasting techniques - time series analysis and Delphi, decision making and talent management PERT, CPM Techniques and time management.

Practical

Managements Information system, in research & development organizations. Study of Management by Course Objective in an organization. Transactional Analysis, exercises on Team building process, coping skills with organizational stress, exercises on Decision Support Systems (DSSs). Practicals exercise on forecasting techniques, Visit to Management organizations.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1.	Management Information System (MIS): Basic concepts	1
2.	Types of information needed at various levels	1
3.	Design of MIS in an agricultural extension organization	1
4.	Scope for computerization, system alternatives and Evaluation	1
5.	Implementation, operation and maintenance of the system.	1
6.	Management by Course Objective (MBO): Elements of the MBO system.	2
7.	The Process of MBO. Making MBO effective.	1
8.	Evaluation of the MBO system - strengths and weaknesses.	2
9.	Transactional Analysis (TA): Ego states, transactions, inter relationships, strokes, stamps.	2
10.	Managing Organizational Stress: Sources of stress in organization, effect of stress.	2
11.	Coping mechanisms and managing stress	1
12.	Stress management	2
13.	Team Building Process: Types of teams. Steps in teamwork	2
14.	Facilitators and barriers to effective relationships, nature of prejudice	1
15.	Tips in reducing interpersonal conflicts	2
16.	Inter-group conflict, resolving techniques.	2
17.	Conflict management, tips in reducing interpersonal conflicts.	2
18.	Decision Support Systems (DSSs): Basic information about Artificial Intelligence (AI) Expert System (ESs), their future applications in extension system.	3
19.	Forecasting techniques - time series analysis and Delphi	1
20.	Decision making and talent management PERT, CPM Techniques and time management.	2

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1.	Managements Information system, in research & development organizations	2

2.	Study of Management by Course Objective in an organization	2
3.	Transactional Analysis	3
4.	Exercises on Team building process	2
5.	Coping skills with organizational stress	2
6.	Exercises on Decision Support Systems (DSSs)	2
7.	Practical exercise on forecasting techniques	2
8.	Visit to Management organizations.	2

Suggested Readings

Chaudhary AK. 1999. *Encyclopedia of Management Information System*. Vols. I, II. Anmol Publ.
 Hari Gopal K. 1995. *Conflict Management - Managing Interpersonal Conflict*. Oxford & IBH.
 James O'Brien 1999. *Management Information System*. Tata McGraw-Hill.
 Koontz H & Welhrich H. 2004. *Essentials of Management*. 5th Ed. Tata. McGraw- Hill.
 Laudon & Laudon 2003. *Management Information System*. Pearson Edu.
 Maheswari BL. 1980. *Organizational Decision Styles & Orgul Effectiveness*. Vikas Publ.
 McGrath SJEH. 2007. *Basic Management Skills for All*. 7th Ed. Prentice Hall of India.
 West JD & Leevy FK. 1998. *A Management Guide to PERT / CPM with GERT / PDM / DCPM and Other Networks*.
 Prentice Hall of India.

List of Journals

- Agricultural Extension Review
- European Journal of Agricultural Education and Extension
- Indian Journal of Social Work
- International Journal of Business and Globalization
- International Journal of Sustainable Development
- Journal of Extension
- Journal of Asia Entrepreneurship and Sustainability
- Journal of Environmental Extension
- Journal of Extension Education
- Journal of International Agriculture and Extension Education
- Journal of Rural Development
- British Journal of Educational Technology
- Economic and Political Weekly
- Indian Economic Panorama
- Indian Journal of Adult Education
- Indian Journal of Extension Education
- Indian Journal of Human Development
- Indian Journal of Open Learning
- Indian Journal of Social Development
- Indian Journal of Training and Development
- Indian Social Science Review
- Journal of Extension System
- Journal of Development Studies
- Journal of Educational Planning and Administration
- Journal of Educational Psychology
- Journal of Environmental Studies and Policy
- Journal of Sustainable Agriculture
- The Journal of Entrepreneurship

e- Resources

- www.pearsoned.com (Pearson Education Publication)
- www.mcgraw-hill.com (McGraw-Hill Publishing Company)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage publications)
- www.macmillanindia.com (Macmillan Publishing)

- www.krishiworld.com (Agriculture Portal)
- www.aiaee.org (The Association for International Agricultural and Extension Education)
- www.geogate.org (Agriculture Portal)

HORTICULTURE

(A). M.Sc. courses:

S. NO.	Course No.	Title	Cr. Hrs.
I Semester			
1.	Hort. 511	Tropical and Dry land Horticulture	3 (2+1)
2.	Hort. 512	Sub-Tropical and Temperate Fruit Production	3 (2+1)
3.	Hort. 513	Production Technology of warm season Vegetable Crops	3 (2+1)
II Semester			
4.	Hort. 521	Seed Production Technology of vegetable crops	3 (2+1)
5.	Hort. 522	Propagation and Nursery management of Fruit Crops	3 (2+1)
6.	Hort. 527	Landscaping and Ornamental Gardening	3 (2+1)
III Semester			
7.	Hort. 531	Production Technology of loose flowers	3 (2+1)
8.	Hort. 532	Post Harvest Technology for Fruit Crops	3 (2+1)
9.	Hort. 533	Production Technology of cool season vegetable crops	3 (2+1)
IV Semester			
10.	Hort. 541	Seminar	0+1
11.	Hort. 542	Comprehensive	0+2
12.	Hort. 543	Master's Research	15

(B). Ph.D.

1.	Hort. 613	Advances in breeding of fruit crops	3 (2+1)
2.	Hort. 614	Advances in breeding of vegetable crops	3 (2+1)
3.	Hort. 621	Advances in Production of fruit crops	3 (2+1)
4.	Hort. 622	Advances in Vegetable production	3 (2+1)
5.	Hort. 641	Seminar	0+2
6.	Hort. 642	Preliminary	0+4
7.	Hort. 643	Doctoral Research	40

HORT 511**Tropical and Dry Land Fruit Production****3(2+1)****Objective**

To impart basic knowledge about the importance and management of tropical and dry land fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports. **Crops**

Mango and Banana, Papaya, Coconut and Cashew nut, Sapota and Jackfruit, Pineapple and Annonas , Aonla, Pomegranate, Phalsa and Ber, minor fruits of tropics (Mahua, Lasoda, Mulberry, Tamarind and Chironji)

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, Practices of important agro-techniques, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

Lecture schedule : Theory

S.No.	Topic	No. of lecture
1.	Commercial varieties of regional , national and international importance, ecophysiological requiriment, recent trends in propagation, rootstock influence, planting system, cropping system, root zone and canopy management, nutrient management, water management, fertigation, role of bio regulators, abiotic factors limiting fruit pdiduction, physiology of flowering , pollination, fruit set and development, honeybees in cross pollination, physiological disorder-causes and remedies, quality improvement by management practices, maturity indices, harvesting, grading, packing, storage and ripening techniques, industrial and export potential, Agri. Export Zones (AEZ) and industrial supports.- Mango	5
2.	Banana	4
3.	Papaya	2
4.	Coconut	2
5.	Cashew nut	2
6.	Sapota	2
7.	Jackfruit	1
8.	Pinaapple	2
9.	Annonas	2
10.	Aonla	2
11.	Pomegranate	1
12.	Phalsa	1
13.	Ber	2
14.	Mahua	1
15.	Lasoda	1
16.	Mulberry	1
17.	Tamarind	1
18.	Chironji	1

Lecture schedule : Practical

1	Identification of important cultivars	2
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2.	Observation on growth and development	2
3.	Practices in growth regulation	2
4.	Malady diagnosis in fruit crops	2
5	Analyses of quality attributes	2
6	Practices of important agro- techniques- fertilization, manuring, weeding and hoeing pruning and training	3
7	Visit to tropical and arid zone orchard	2
8	Project preparation for establishing commercial orchards	2

Suggested Readings

- Bose, TK, Mitra, SK & Rathore, DS. (Eds.). 1988. *Temperate Fruits - Horticulture*. Allied Publ.
- Bose, T.K, Mitra, S.K & Sanyal, D. 2001. (Eds.). *Fruits -Tropical and Subtropical*. Naya Udyog.
- Chadha, K.L & Pareek, O.P. 1996. (Eds.). *Advances in Horticulture*. Vols. II- IV. Malhotra Publ. House.
- Nakasone, H.Y & Paul, R.E. 1998. *Tropical Fruits*. CABI.
- Peter, K.V. 2008. (Ed.). *Basics of Horticulture*. New India Publ. Agency.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan, K.N. 2008. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
- Radha, T & Mathew, L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh, H.P, Negi JP & Samuel JC. (Eds.). 2002. *Approaches for Sustainable Development of Horticulture*. National Horticultural Board.
- Singh, H.P, Singh G, Samuel, J.C & Pathak R.K. (Eds.). 2003. *Precision Farming in Horticulture*. NCPAH, DAC/PFDC, CISH, Lucknow.

HORT 512

Subtropical and Temperate Fruit Production

3 (2+1)

Objective

To impart basic knowledge about the importance and management of subtropical and temperate fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bio regulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, pre-cooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops- Apple, pear, quince, Plums, peach, apricot, cherries, Litchi, loquat, kiwifruit, strawberry

Nuts- walnut, almond, pistachio, Grapes, Guava, Citrus and Custard apple, Minor fruits- carambola, bael, wood apple, fig, jamun, rambutan, ker, pilu

Practical

Identification of important fruit plants and its available cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical, subtropical, humid tropical and temperate orchards, Project preparation for establishing commercial orchards.

Lecture schedule: Theory

S. No	Topic	No. of lectures
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1	Commercial varieties of regional, national and international importance, cophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water anagement, fertigation, role of bio regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports of following fruit crops.	
2	Apple, pear, quince	6
3	Plums, peach, apricot, cherries	4
4	Litchi, loquat, kiwifruit, strawberry	4
5	Nuts- walnut, almond, pistachio	4
6	Grapes, Guava, Citrus and Custard apple	6
7	Minor fruits- carambola, bael, wood apple, fig, jamun, rambutan, ker, pilu	8

Lecture schedule: Practical

1	Identification of important fruit plants and its available cultivars	2
2	Observations on growth and development of Tropical, sub- tropical & temperate fruit crops.	2
3	Practices in growth regulation and canopy management in fruit crops	4
4	Diagnosis of different malady / disorders & analyses of quality attributes	4
5	Practices of important agro-techniques of tropical, sub- tropical & temperate fruit crops.	2
6	Visit to tropical, sub- tropical & temperate fruit crops.	2

Suggested Readings

- Bose T.K, Mitra S.K & Sanyal D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha K.L & Pareek O.P. 1996. (Eds.). *Advances in Horticulture*. Vol. I. Malhotra Publ. House.
- Chadha K.L & Shikhamany S.D. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.
- Janick J & Moore J.N. 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). *Fruit Breeding in India*. Oxford & IBH.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh S, Shivankar V.J, Srivastava A.K & Singh I.P. (Eds.). 2004. *Advances in Citriculture*. Jagminder Book Agency.

HORT 513 Production Technology of Warm Season Vegetable Crops 3(2+1)

Objective

To teach production technology of warm season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of: Tomato, eggplant, hot and sweet peppers, Okra, beans, cowpea and clusterbean, Cucurbitaceous crops , Colocasia and sweet potato, Green leafy warm season vegetables.

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and

diseases and their control; maturity standards; economics of warm season vegetable crops.

Lecture schedule: Theory

S.No.	Topic	No. of lecture
1.	Introduction, botany & taxonomy, climate and soil requirement, commercial varieties/hybrids, sowing/planting times & methods, seed rate and seed treatment, nutritional and irrigation requirement, intercultural operations, weed control, mulching, physiological disorder, harvesting, post-harvesting management, plant protection measures, economics of crop production and seed production of - Tomato	4
2.	Eggplant	3
3.	Hot and sweet peppers	3
4.	Okra	1
5.	Beans	2
6.	Cowpea	1
7.	Cluster bean	1
8.	Cucurbitaceous crops- Water melon	1
9.	Musk melon	1
10.	Bottle gourd	1
11.	Ridge gourd	1
12.	Round gourd	1
13.	Kakri	1
14.	Bitter gourd	1
15.	Little gourd	1
16.	Smooth gourd	1
17.	Snap gourd	1
18.	Kachari	1
19.	Khira	1
20.	Kaddu	1
21.	Colocasia	2
22.	Sweet potato	1
23.	Green leafy warm season vegetables	1

Lecture schedule: Practical

S.No	Topic	No. of lecture
1.	Cultural operations (fertilizer application, sowing, mulching)	1
2.	Cultural operations (irrigation and weed control) of summer vegetables crops	1
3.	Economic of summer veg, crops	1
4.	Study of physiological and deficiency of mineral elements	2
5.	Preparation of cropping schemes for commercial farms	1
6.	Experiments to demonstrate the role of mineral element physiological disorder	1
7.	Experiments to demonstrate the physiological disorder	1
8.	Experiments to demonstrate the plant growth substances	1
9.	Experiments to demonstrate the herbicides	1
10.	Experiments to demonstrate the seed extraction techniques	1
11.	Identification of important pests and their control	1
12.	Identification of important diseases and their control	1
13.	Maturity standard of warm season vegetables crops	1
14.	Economics of warm season vegetables crops	2

Suggested Readings

Bose T.K & Som M.G. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.

Bose T.K, Kabir J, Maity T.K, Parthasarathy V.A & Som M.G. 2003. *Vegetable Crops*. vols. I-III. Naya

Udyog.

- Bose T.K, Som M.G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Brown H.D & Hutchison C.S. *Vegetable Science*. JB Lippincott Co.
- Chadha K.L & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture*. vols. V-X. Malhotra Publ. House.
- Chadha K.L. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan D.V.S. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Decoteau D.R. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond J.B, Musser A.M & Andrews F.S. 1964. *Fundamentals of Horticulture*. Blakiston Co
- Fageria M.S, Choudhary B.R & Dhaka R.S. 2000. *Vegetable Crops: Production Technology*. vol. II. Kalyani.
- Gopalakrishanan T.R. 2007. *Vegetable Crops*. New India Publ. Agency.
- Hazra P & Som M.G. (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Kaloo G & Singh K (Ed.). 2000. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.
- Nayer N.M & More TA 1998. *Cucurbits*. Oxford & IBH Publ.
- Palaniswamy & Peter Ky. 2007. *Tuber Crops*. New India Publ. Agency.
- Pandey A.K & Mudranalay y. (Eds.). *Vegetable Production in India: Important Varieties and Development Techniques*.
- Rana M.K. 2008. *Olericulture in India*. Kalyani.
- Rana M.K. 2008. *Scientific Cultivation of Vegetables*. Kalyani.
- Rubatzky V.E & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
- Saini G.S. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
- Salunkhe D.K & Kadam S.S. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
- Shanmugavelu K.G. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.
- Singh D.K. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
- Singh N.P, Bharadwaj A.K, Kumar A & Singh K.M. 2004. *Modern Technology on Vegetable Production*. International Book Distributing Co.
- Singh SP. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson H.C & Kelly W.C. (Eds.). 1978. *Vegetable Crops*. Tata Mc Graw Hill.

HORT 521

Seed Production Technology of Vegetable Crops

3(2+1)

Objective

To educate principles and methods of quality seed and planting material production in vegetable crops.

Theory

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India. Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production. Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control. Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology. Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Lecture schedule: Theory

S.No.	Topic	No. of lecture
1.	Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.	2
2.	Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.	2
3.	Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.	2
4.	Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.	2
5.	Agro-techniques for seed production in potato	2
6.	Tomato	2
7.	Brinjal	2
8.	Chilli	2
9.	Cauliflower	1
10.	Cabbage	1
11.	Knol-khol	1
12.	Sprouting broccoli	1
13.	Bussels sprout	1
14.	Okra	1
15.	Cucurbitaceous crops	2
16.	Onion	1
17.	Garlic	1
18.	Pea	1
19.	Broad bean	1
20.	Cluster bean	1
21.	Cow pea	1
22.	Palak	1
23.	Amaranthus	1
24.	Fenugreek	1

Lecture schedule: Practical

S.No	Topic	No. of lecture
1.	Seed sampling	2
2.	Seed testing (genetic purity, seed viability)	2
3.	Seed viability	2
4.	Seedling vigour	2
5.	Physical purity) and seed health testing	2
6.	Releasing and notification procedures of varieties	2
7.	Floral biology	2
8.	Rouging	2

Suggested Readings

- Agrawal P.K & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Agrawal R.L. (Ed.). 1997. *Seed Technology*. Oxford & IBH.
- Bendell P.E. (Ed.). 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publ.
- Fageria M.S, Arya P.S & Choudhary A.K. 2000. *Vegetable Crops: Breeding and Seed Production*. vol. I. Kalyani.
- George RAT. 1999. *Vegetable Seed Production*. 2nd Ed. CABI.

- Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
- More T.A, Kale P.B & Khule B.W. 1996. *Vegetable Seed production Technology*. Maharashtra State Seed Corp.
- Rajan S & Baby L Markose. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.
- Singh N.P, Singh D.K, Singh Y.K & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.
- Singh S.P. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

HORT 522 Propagation and Nursery Management for Fruit Crops

3(2+1)

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification, testing. Asexual propagation – rooting of cuttings. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting-selection of elite mother plants, methods. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank. Micro-propagation– principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micro grafting, meristem culture. Hardening, packing and transport of micro-propagules, shoot tip grafting/ micro grafting. Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Preparation and planting of cuttings and layering, Root stock raising, Practices of different methods of budding and grafting, Study of media and PGR. Hardening, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Lecture schedule: Theory

S. No.	Topic	No. of lectures
1	Introduction, life cycles in plants	1
2	Cellular basis for propagation in fruit crops.	1
3	Sexual propagation, apomixis, polyembryony, chimeras.	2
4	Principal factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.	2
5	Seed quality, treatment, packing, storage, certification, testing	2
6	Asexual propagation – rooting of cuttings.	3
7	Physiological, anatomical and biochemical aspects of root induction in cuttings.	2
8	Layering – principle and methods.	2
9	Budding and grafting-selection of elite mother plants, methods.	2
10	Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility.	2
11	Rejuvenation through top working – Progeny orchard and scion bank.	2
12	Micro-propagation–principles and concepts, commercial exploitation in horticultural crops.	2
13	Techniques - <i>in vitro</i> clonal propagation, direct organogenesis, embryogenesis, micro grafting, meristem culture	2
14	Hardening, packing and transport of micro-propagules, shoot tip grafting/ micro grafting.	2
15	Nursery – types, structures, components, planning and layout.	2

16	Nursery management practices for healthy propagule production.	3
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Lecture schedule: Practical

1	Preparation and planting of cuttings and layering	2
2	Raising of root stock.	2
3	Practices of different methods of budding and grafting	4
4	Study of media and PGR	2
5	Hardening, micro propagation, explant preparation, media preparation	2
6	<i>In vitro</i> clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening.	2
7	Visit to TC labs and nurseries.	2

Suggested Readings

- Hartmann H.T & Kester D.E. 1989. *Plant Propagation – Principles and Practices*. Prentice Hall of India.
 Bose T.K, Mitra S.K & Sadhu M.K. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash.
 Peter KV. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency. Singh SP. 1989 *Mist Propagation*. Metropolitan Book Co.
 Rajan S & Baby LM. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.
 Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

HORT 527 Landscaping and Ornamental Gardening 3(2+1)

Objective

Familiarization with principles and practices of landscaping and ornamental gardening.

Theory

Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Buddha garden; Styles of garden, formal, informal and free style gardens. Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates. Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants. Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Identification of ornamental plants, practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Lecture schedule: Theory

S. No.	Topic	No. of lecture
1	Scope of loose flower trade, Significance in the domestic market export	2
2	Varietal wealth and diversity	1
3	Propagation: Sexual and asexual propagation methods	3
4	Propagation in mist chambers, nursery management, pro-tray nursery under shade nets, transplanting techniques	2
	Soil and climate requirements, field preparation, systems of planting, precision farming techniques, Water and nutrient management, weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, 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, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones	
5	Jasmine	2
6	Scented rose	3
7	Chrysanthemum	3
8	Marigold	1
9	Tuberose	1
10	Crossandra	1
11	Nerium	1
12	Hibiscus	1
13	Barleria	1
14	Gomphrena	1
15	Gaillardia	1
16	Nyctanthes	1
17	Tabernaemontana	1
18	Ixora,	1
19	Lotus	1
20	Lilies	1
21	Tecoma	1
22	Champaka	1
23	Pandanus	1

Lecture schedule: Practical

S. No.	Topic	No. of lecture
1	Botanical description of species and varieties	1
2	Propagation techniques	2
3	Mist chamber operation	1
4	Training and pruning techniques	1
5	Practices in manuring, drip and fertigation, foliar nutrition,	2
6	Growth regulator application	1
7	Pinching, disbudding, staking	1
8	Harvesting techniques	1
9	Post-harvest handling,	1
10	Storage and cold chain,	1
11	Project preparation for regionally important commercial loose flowers	2
12	Essential oil extraction units and markets	1
13	Visits to fields	1

Suggested Readings

Bose T.K, Maiti R.G, Dhua R.S & Das P.1999. *Floriculture and Landscaping*. Naya Prakash.
Lauria A & Yictor H.R. 2001. *Floriculture – Fundamentals and Practices* Agrobios.
Nambisan K.M.P.1992. *Design Elements of Landscape Gardening*. Oxford & IBH.
Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
Sabina G.T & Peter K.Y. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.

HORT 531

Production Technology for Loose Flowers

3(2+1)

Objective

To impart basic knowledge about the importance and management of loose flowers grown in India.

Theory

Scope of loose flower trade, Significance in the domestic market export, varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques

Soil and climate requirements, field preparation, systems of planting, precision farming techniques. Water and nutrient management, weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, 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, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones. **Crops:** Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, gomphrena, gaillardia, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Lecture schedule:Theory

S. No.	Topic	No. of lectures
1	Landscape designs	1
2	Styles of garden, formal, informal and free style gardens	1
3	Mughal garden	1
4	English Garden	1
5	Japanese garden	1
6	Persian garden, Spanish garden, Italian & Buddha garden	2
7	Urban landscaping	1
8	Landscaping for specific situations: Institutions	1
9	Landscaping for specific situations: Industries	1
10	Landscaping for specific situations: Residents & hospitals, Roadsides, traffic islands, damsites	2
11	Landscaping for specific situations: IT parks & corporate	1
12	Garden plant components, arboretum	1
13	Shrubbery	1
14	Fernery, palmatum	1
15	Arches and pergolas	1
16	Edges and Hedges	1
17	Climbers and creepers	1
18	Cacti and succulents	1
19	Herbs, annuals, flower borders and beds	1
20	Ground covers, carpet beds, bamboo groves	1
21	Production technology for selected ornamental plant	1
22	Lawns: Establishment and maintenance	1
23	Special types of gardens: vertical garden, roof garden,	1
24	Bog garden, sunken garden	1
25	Rock garden, clock garden, colour wheels, temple garden, sacred groves	1
26	Bio-aesthetic planning, eco-tourism, theme parks	1
27	Indoor gardening	1
28	Therapeutic gardening, non-plant components	1
29	Water scaping	1
30	Xeriscaping & hardscaping	1

Lecture schedule: Practical

S. No.	Topic	No. of lectures
1	Identification of ornamental plants	2
2	Practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates	4
3	Avenue planting, practices in planning and planting of special types of gardens, burlapping	2
4	Lawn making	2
5	Planting herbaceous and shrubbery borders	1
6	Project preparation on landscaping for different situations	2
7	Visit to parks and botanical gardens	1
8	Case study on commercial landscape gardens	2

Suggested Readings

- Arora J.S. 2006. *Introductory Ornamental Horticulture*. Kalyani.
Bhattacharjee S.K. 2006. *Advances in Ornamental Horticulture*. vols. I-VI. Pointer Publ.
Bose T.K & Yadav LP. 1989. *Commercial Flowers*. Naya Prokash.
Bose T.K, Maiti R.G, Dhua R.S & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
Chadha K.L & Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR.
Chadha K.L. 1995. *Advances in Horticulture*. vol. XII. Malhotra Publ. House.
Lauria A & Ries V.H. 2001. *Floriculture – Fundamentals and Practices*. Agrobios.
Prasad S & Kumar U. 2003. *Commercial Floriculture*. Agrobios.
Randhawa G.S & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
Sheela V.L. 2007. *Flowers in Trade*. New India Publ. Agency.
Valsalakumari P.K, Rajeevan P.K, Sudhadevi P.K & Geetha C.K. 2008. *Flowering Trees*. New India Publ. Agency.

HORT 532

Post Harvest Technology for Fruit Crops

3(2+1)

Objective

To facilitate deeper understanding on principles and practices of post-harvest management of fruit crops.

Theory

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling. Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders. Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juice beverages, pickles, jam, jellies, sauces and ketchup, candies, preserve. Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of shelf life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, practices of preservation by salt, sugar, vinegar and chemical preservatives, cold chain management - visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1	Maturity indices,	2
2	harvesting practices for specific market requirements,	1
3	influence of pre-harvest practices,	2
4	enzymatic and textural changes, respiration, transpiration.	2
5	Physiology and biochemistry of fruit ripening	1
6	ethylene evolution and ethylene management,	1
7	factors leading to post-harvest loss.	1
8	Treatments prior to shipment, viz., pre-cooling, chlorination, waxing, chemicals, biocontrol agents and natural plant products.	2
9	Methods of storage- ventilated, refrigerated, MAS, CA storage	3
10	, physical injuries and disorders.	1
11	Packing methods and transport,	2
12	principles and methods of preservation, food processing,	2
13	canning,	1
14	fruit juice beverages,	1
15	pickles,	1
16	jam,	1
17	jellies,	1
18	sauces and ketchup,	1
19	Candies & preserve.	1
20	Dried and dehydrated products,	1
21	nutritionally enriched products,	1
22	fermented fruit beverages,	1
23	packaging technology, processing waste management,	1
24	food safety standards.	1

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	Analyzing maturity stages of commercially important horticultural crops	1
2	improved packing and storage of important horticultural commodities	1
3	physiological loss in weight of fruits and vegetables	1
4	estimation of transpiration, respiration rate, ethylene release	2
5	study of shelf life extension in cut flower using chemicals	2
6	estimation of quality characteristics in stored fruits and vegetables	3
7	practices of preservation by salt, sugar, vinegar and chemical preservatives	2
8	cold chain management - visit to cold storage and CA storage units	1
9	visit to fruit and vegetable processing units	1
10	project preparation	1
11	evaluation of processed horticultural products	1

Suggested Readings

- Bhutani R.C. 2003. *Fruit and Vegetable Preservation*. Biotech Books.
- Chadha K.L & Pareek O.P. (Eds.). 1996 *Advances in Horticulture*. Vol. IV. Malhotra Publ. House.
- Haid N.F & Salunkhe S.K. 1997. *Post Harvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.
- Mitra S.K. 1997. *Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits*. CABI.
- Ranganna S. 1997. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.
- Sudheer K.P & Indira V. 2007. *Post Harvest Technology of Horticultural Crops*. New India Publ. Agency.
- Willis R, Mc Glassen W.B, Graham D & Joyce D. 1998. *Post Harvest. An Introduction to the Physiology and*

HORT 533 Production Technology of Cool Season Vegetable Crops 3(2+1)

Objective

To educate production technology of cool season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of: Potato ,Cole crops: cabbage, cauliflower, knol-kohl, sprouting broccoli, Brussels sprout, Root crops: carrot, radish, turnip and beetroot, Bulb crops: onion and garlic, Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ polyhouse.

Lecture schedule: Theory

S.No.	Topic	No. of lecture
1.	Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production	4
2.	Potato	2
3.	Cabbage	2
4.	Cauliflower	2
5.	Knol-kohl	1
6.	Sprouting broccoli	1
7.	Brussels sprout	1
8.	Onion	2
9.	Garlic	2
10.	Carrot	2
11.	Radish	2
12.	Turnip	1
13.	Beetroot	1
14.	Pea	2
15.	Broad bean	1
16.	Cluster bean	1
17.	Cow pea	1
18.	Palak	1
19.	Amaranthus	1
20.	Fenugreek	1

Lecture schedule: Practical

S.No	Topic	No. of lecture
1.	Identification of vegetable crops and seed.	2
2.	Fertilizer application in vegetable crops	1
3.	Seed treatment in vegetable crops	1
4.	Mulching in vegetable crops	1

5.	Irrigation management in vegetable crops	1
6.	Weed management in vegetable crops	1
7.	Role of mineral nutrition in vegetable crops	1
8.	Role of PGR's in vegetable crops	1
9	Physiological disorders of cole crops	2
10	Physiological disorders of bulb crops	2
11	Physiological disorders of root crops	2
12	Maturity standard of vegetable crops	1

Suggested Readings

- Bose T.K & Som M.G. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
- Bose T.K, Som G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Bose T.K, Som M.G & Kabir J. (Eds.). 1993. *Vegetable Crops*. Naya Prokash.
- Bose T.K, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. vols. I-III. Naya Udyog.
- Chadha K.L & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture* vols. V-X. Malhotra Publ. House.
- Chadha K.L. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan D.V.S. (Ed.). 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Decoteau D.R. 2000. *Vegetable Crops*. Prentice Hall.
- Edmond J.B, Musser A.M & Andrews F.S. 1951. *Fundamentals of Horticulture*. Blakiston Co.
- Fageria M.S, Choudhary B.R & Dhaka R.S. 2000. *Vegetable Crops: Production Technology*. vol. II. Kalyani.
- Gopalakrishanan T.R. 2007. *Vegetable Crops*. New India Publ. Agency.
- Hazra P & Som MG. (Eds.). 1999. *Technology for vegetable Production and Improvement*. Naya Prokash.
- Rana M.K. 2008. *Olericulture in India*. Kalyani Publ.
- Rana M.K. 2008. *Scientific Cultivation of Vegetables*. Kalyani Publ.
- Rubatzky Y.E & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
- Saini G.S. 2001. *A Text Book of Oleri and Flori Culture*. Aman Publ. House.
- Salunkhe D.K & Kadam S.S. (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel Dekker.
- Shanmugavelu K.G. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.
- Singh D.K. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.
- Singh S.P. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson H.C & Kelly W.C. (Eds.). 1978. *Vegetable Crops*. Tata McGraw- Hill.

Ph.D Programme

HORT 613

Advances in Breeding of Fruit Crops

3(2+1)

Objective

To update knowledge on the recent research trends in the field of breeding of fruit crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits, recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops. Mango and banana, Papaya, grapes and citrus, Guava and sapota, Pineapple and avocado, Apple, pear, plums, peaches, apricot, cherries and strawberry.

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination-isozyme techniques-survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1	Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits , recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.	4
2	Mango	3
3	Banana	3
4	Papaya	2
5	Grapes	2
6	Citrus	3
7	Guava	2
8	Sapota	2
9	Pineapple	1
10	Avocado	1
11	Apple	3
12	pear,	1
13	plums,	1
14	peaches,	1
15	apricot,	1
16	Cherries	1
17	Strawberry	1

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	Description and cataloguing of germplasm,	3
2	pollen viability tests,	1
3	pollen germination-isozyme techniques-survey and clonal selection,	2
4	observations on pest, disease and stress reactions in inbreds and hybrids,	3
5	use of mutagenes and colchicine for inducing mutation and ploidy changes	3
6	, practices in different methods of breeding fruit crops and in-vitro breeding techniques.	4

Suggested Readings

- Bose T.K, Mitra S.K & Sanyal D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek O.P. (Eds.). 1996. *Advances in Horticulture*. Vol. I. Malhotra Publ. House.
- Chadha K.L & Shikhamany S.D. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.
- Gowen S. 1996. *Banana and Plantains*. Chapman & Hall.
- Janick J & Moore JN. 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons.
- Nijjar G.S. (Ed.). 1977. *Fruit Breeding in India*. Oxford & IBH.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Singh S, Shivankar V.J, Srivastava A.K & Singh I.P. (Eds.). 2004. *Advances in Citriculture*. Jagminder Book Agency.
- Stover R.H & Simmonds N.W. 1991. *Bananas*. Longman.

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of: Tomato, brinjal, chilli, sweet pepper and potato, Cucurbits, Cabbage, cauliflower and knol-khol, Bhindi, onion, peas and beans, amaranthus and drumstick, Carrot, beet root and radish, Sweet potato, tapioca, elephant foot yam and taro.

Practical

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Lecture schedule: Theory

S.No.	Topic	No. of lectures
1.	Evolution, distribution, cytogenesis, genetic divergence, type of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutation, problems and achievement of mutation breeding, ploidy breeding and its achievement, <i>in vitro</i> breeding; breeding techniques for improving quality and processing characters; breeding for stress, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of - Tomato	3
2.	Brinjal	2
3.	Chilli	2
4.	Sweet pepper	2
5.	Potato	2
6.	Cucurbits	4
7.	Cabbage	2
8.	Cauliflower	1
9.	Knol-khol	1
10.	Bhindi	1
11.	Onion	1
12.	Peas	1
13.	Beans	1
14.	Amaranthus	1
15.	Drumstick	1
16.	Carrot	1
17.	Beet root	1
18.	Radish	1
19.	Sweet potato	1

20.	Tapioca	1
21.	Elephant foot yam	1
22.	Taro	1

Lecture schedule: Practical

S.No	Topic	No. of lecture
1	Designing of breeding experiments	2
2.	Techniques for abiotic stresses	2
3.	Screening and rating for pest, disease and nematode resistance	3
4.	Estimation of quality and processing characters	3
5.	Screening for quality improvement	2
6.	Estimation of heterosis and combining ability	2
7.	Induction and identification of mutants and polyploids	1
8.	Distant hybridization and embryo rescue technique	1

Suggested Readings

- Acta Horticulture*. Conference on Recent Advance in Vegetable Crops. Vol. 127.
Chadha K.L, Ravindran P.N & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
Chadha K.L. 2001. *Hand Book of Horticulture*. ICAR.
Dhillon B.S, Tyagi R.K, Saxena S & Randhawa G.J. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.
Janick J.J. 1986. *Horticultural Science*. 4th Ed. WH Freeman & Co.
Kaloo G & Singh K. 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals and Book Publ. House.
Kaloo G. 1994. *Vegetable Breeding*. Vols. I-III. Vedams eBooks.
Peter K.V & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised Ed.). ICAR.
Ram H.H. 2001. *Vegetable Breeding*. Kalyani.

HORT 621

Advances in Production of Fruit Crops

3(2+1)

Objective

To keep abreast with latest developments and trends in production technology of fruit crops.

Theory

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling , Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, , Total quality management(TQM) - Current topics. Mango and banana, Papaya, grapes and citrus, Guava, sapota, pomegranate and aonla, Pineapple, avocado, jack fruit and fig, Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency- estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis.

S.No.	Topic	No. of lectures
1	National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling , Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Total quality management(TQM) - Current topics.	3
2	Mango	3
3	Banana	2
4	Papaya	1
5	Grapes	2
6	Citrus	3
7	Guava	1
8	Sapota	1
9	Pomegranate	1
10	Aonla	1
11	Pineapple	1
12	Avocado	1
13	jack fruit	1
14	Fig	1
15	Apple	3
16	pear,	1
17	plums,	1
18	peaches,	1
19	apricot,	1
20	Cherries	1
21	Strawberry	1
22	nut crops	1

Lecture schedule: Practical

S.No.	Topic	No. of lectures
1	Survey of existing fruit cropping systems and development of a model cropping system.	4
2	Estimating nutrient deficiency.	4
3	Estimation of water use efficiency.	1
4	Soil test-crop response correlations.	2
5	Practices in plant growth regulation.	2
6	Studying physiological and biochemical responses, quality analysis.	3

Suggested Readings

- Bose T.K, Mitra S.K & Rathore D.S. (Eds.). 1988. *Temperate Fruits – Horticulture*. Allied Publ.
- Bose T.K, Mitra S.K & Sanyal D. (Eds.). 2001. *Fruits -Tropical and Subtropical*. Naya Udyog.
- Bose T.K, Mitra S.K, Farooqi A.A & Sadhu M.K. 1999. *Tropical Horticulture*. Vol. I. Naya Prokash.
- Chadha K.L & Pareek O.P. (Eds.).1996. *Advances in Horticulture*. Vols. IIIIV. Malhotra Publishing House.
- Chadha K.L. 2001. *Handbook of Horticulture*. ICAR.
- Nakasone H.Y & Paull R.E. 1998. *Tropical Fruits*. CABI.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

Objective

To keep abreast with latest developments and trends in production technology of vegetable crops.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of: Tomato, brinjal, chilli, sweet pepper and potato, Cucurbits, cabbage, cauliflower and knol-khol, Bhendi, onion, peas and beans, amaranthus and drumstick, Carrot, beet root and radish, Sweet potato, tapioca, elephant foot yam and taro.

Practical

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices; dryland techniques for rainfed vegetable production; production constraints; analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis ;marketing survey of the above crops; visit to vegetable and fruit mals and packing houses.

Lecture schedule: Theory

S.No.	Topic	No. of lecture
1.	Present status and prospect of vegetables cultivation; nutritional and medicinal value; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrient and biofertilizers; response of genotypes to low and high nutrient management, nutritional defeiciencies, disorder and correction methods; different cropping systems, mulching; containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modeling, organic gardening, vegetable production for pigments, export and processing of- Tomato	3
2.	Brinjal	2
3.	Chilli	2
4.	Sweet pepper	2
5.	Potato	2
6.	Cucurbits	4
7.	Cabbage	2
8.	Cauliflower	1
9.	Knol-khol	1
10.	Bhindi	1
11.	Onion	1
12.	Peas	1
13.	Beans	1
14.	Amaranthus	1
15.	Drumstick	1
16.	Carrot	1
17.	Beet root	1
18.	Radish	1
19.	Sweet potato	1
20.	Tapioca	1
21.	Elephant foot yam	1
22.	Taro	1

Lecture schedule: Practical

S.No	Topic	No.of lecture
1.	Seed hardening	1
2.	Practices in indeterminate and determinate vegetable growing and organic gardening	1
3.	Portrays and ball culture	1
4.	Diagnosis of nutritional and physiological disorders	1
5.	Analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation	1
6.	Assessing nutrient status	1
7.	Use of plant growth regulators	1
8.	Practices in herbicide application practices in herbicide application	1
9.	Estimating water requirements in relation to crop growth stages	1
10.	Maturity indices	1
11.	Dryland techniques for rainfed vegetable production	1
12.	Production constraints	1
13.	analysis of different cropping system in various situation like cold and hot set;	1
14.	Vegetable waste recycling management	1
15.	Quality analysis ;marketing survey of the above crops	1
16.	Marketing survey of the above crops; visit to vegetable and fruit mals and packing houses	1

Suggested Readings

- Bose T.K & Som N.G. 1986. *Vegetable Crops of India*. Naya Prakash.
- Bose T.K, Kabir J, Maity T.K, Parthasarathy V.A & Som M.G. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
- Brewster J.L. 1994. *Onions and other Vegetable Alliums*. CABI. FFTC. *Improved Vegetable Production in Asia*. Book Series No. 36.
- Ghosh S.P, Ramanujam T, Jos J.S, Moorthy S.N & Nair R.G. 1988. *Tuber Crops*. Oxford & IBH.
- Gopalakrishnan T.R. 2007. *Vegetable Crops*. New India Publishing Agency.
- Kallo G & Singh K. (Ed.). 2001. *Emerging Scenario in Vegetable Research and Development*. Research Periodicals & Book Publ. House.
- Kurup G.T, Palanisami M.S, Potty V.P, Padmaja G, Kabeerathuma S & Pallai SV. 1996. *Tropical Tuber Crops, Problems, Prospects and Future Strategies*. Oxford & IBH.
- Sin M.T & Onwueme I.C. 1978. *The Tropical Tuber Crops*. John Wiley & Sons.
- Singh N.P, Bhardwaj A.K, Kumar A & Singh K.M. 2004. *Modern Technology on Vegetable Production*. International Book Distr. Co.
- Singh P.K, Dasgupta S.K & Tripathi S.K. 2006. *Hybrid Vegetable Development*. International Book Distr. Co.

List of Journals & Magazines**FRUIT SCIENCE**

- Acta Horticulture
- Haryana Journal of Horticulture Science
- Horticulture Reviews
- HortScience
- Indian Horticulture
- Indian Journal of Arid Horticulture
- Indian Journal of Horticulture
- Journal of American Society of Horticultural Sciences
- Journal of Applied Horticulture
- Journal of Horticultural Sciences
- Journal of Horticultural Sciences & Biotechnology
- Journal of Japanese Society for Horticulture Science

- Journal of Korean Society for Horticulture Science
- Scientia Horticulture
- South Indian Horticulture

VEGETABLE SCIENCE

- American Journal of Horticultural Sciences
- American Potato Growers
- American Scientist
- Annals of Agricultural Research
- Annual Review of Plant Physiology
- California Agriculture
- Haryana Journal of Horticultural Sciences
- HAU Journal of Research
- Horticulture Research
- HortScience
- IIVR Bulletins
- Indian Horticulture
- Indian Journal of Agricultural Sciences
- Indian Journal of Horticulture
- Indian Journal of Plant Physiology
- Journal of American Society for Horticultural Sciences
- Journal of Arecanut and Spice Crop
- Journal of Food Science and Technology
- Journal of Plant Physiology
- Journal of Post-harvest Biology and Technology
- Post-harvest Biology and Technology
- Scientia Horticulturae
- Seed Research
- Seed Science
- South Indian Horticulture
- Vegetable Grower
- Vegetable Science

FLORICULTURE AND LANDSCAPE ARCHITECTURE

- Acta Horticulture
- Floriculture Today
- Haryana Journal of Horticulture Science
- Horticulture Reviews
- HortScience
- Indian Horticulture
- Indian Journal of Arid Horticulture
- Indian Journal of Horticulture
- Journal of American Society of Horticultural Sciences
- Journal of Applied Horticulture
- Journal of Horticultural Sciences
- Journal of Horticultural Sciences & Biotechnology
- Journal of Japanese Society for Horticulture Science
- Journal of Korean Society for Horticulture Science
- Journal of Landscape architecture
- Journal of Ornamental Horticulture
- Scientia Horticulture
- South Indian Horticulture

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

- Acta Horticulture
- Haryana Journal of Horticulture Science
- Horticulture Reviews
- HortScience

- Indian Horticulture
- Indian Journal of Arid Horticulture
- Indian Journal of Horticulture
- Indian Spice
- Journal of American Society of Horticultural Sciences
- Journal of Applied Horticulture
- Journal of Horticultural Sciences
- Journal of Horticultural Sciences & Biotechnology
- Journal of Japanese Society for Horticulture Science
- Journal of Korean Society for Horticulture Science
- Journal of Plantation Crops
- Journal of Spices and Aromatic Crops
- Scientia Horticulture
- South Indian Horticulture
- Spice India

e - Resources in Horticulture

Australian Society for Horticultural Science <http://www.aushs.org.au/>
 Agricultural & Processed Food Products Export Development Authority (APEDA) <http://www.apeda.com/>
 American Society for Horticultural Science <http://www.ashs.org/>
 Asian Vegetable Research and Development Center (AVRDC) <http://www.avrdc.org.tw/>
 Australian Society for Horticultural Science <http://www.aushs.org.au/>
 Central Food Technological Research Institute (CFTRI) <http://www.cftri.com/>
 Central Institute of Medicinal & Aromatic Plants (CIMAP) <http://www.cimap.org/>
 Central Institute of Post harvest Engineering and Technology <http://www.icar.org.in/ciphet.html>
 Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala <http://cpcri.nic.in/>
 Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram <http://www.ctcri.org/>
 Consultative Group on International Agricultural Research, CGIAR <http://www.cgiar.org/>
 Coffee Board, India <http://indiacoffee.org/>
 Department of Agriculture and Co-operation, India <http://agricoop.nic.in/>
 Department of Scientific and Industrial Research, India <http://dsir.nic.in/> FAO <http://www.fao.org/>
 Global Agribusiness Information Network: <http://www.fintrac.com/gain/>
 Greenhouse Vegetable Information: <http://www.ghvi.co.nz/>
 Indian Agricultural Research Institute (IARI) <http://www.iari.res.in/>
 Indian Council of Agricultural Research (ICAR) <http://www.icar.org.in>
 Indian Institute of Horticultural Research (IIHR) www.iihr.res.in
 Indian Institute of Spices Research (IISR), Calicut, Kerala <http://www.iisr.org/>
 Indo-American Hybrid Seeds www.indamseeds.com
 Institute of Vegetable and Ornamental Crops <http://www.igzev.de/>
 Institute for Horticultural Development, Victoria, Australia <http://www.nre.vic.gov.au/agvic/ih/>
 Kerala Agricultural University www.kau.edu
 Iowa State University Department of Horticulture <http://www.hort.iastate.edu/>
 National Bureau of Plant Genetic Resources (NBPGR), India <http://nbpgr.delhi.nic.in/>
 National Horticulture Board (NHB), India <http://hortibizindia.nic.in/>
 National Institute of Agricultural Extension Management (MANAGE), <http://www.manage.gov.in/>
 National Research Centre for Cashew (NRCC), <http://kar.nic.in/cashew/> India
 National Research Centre for Mushroom (NRCM), India <http://www.nrcmushroom.com/>
 National Research Centre for Oil Palm (NRCOP), India <http://www.ap.nic.in/nrcop>
 North Carolina State University, Dept. of Horticulture http://www2.ncsu.edu/cals/hort_sci/
 Oregon State University, Dept. of Horticulture <http://osu.orst.edu/dept/hort>
 Pineapple News <http://agrss.sherman.hawaii.edu/pin> eapple/pineappl.htm
 Pomology Resources Center <http://www.bsi.fr/pomologie/english/> /pomology:
 Rubber board, India <http://rubberboard.org.in/>
 Spice Paprika web site <http://www.paprika.deltav.hu/>
 Spices Board, India <http://www.indianspices.com/>
 Sri Lanka Agribusiness on-line <http://www.agro-lanka.org/>
 Sustainable Apple Production: <http://orchard.uvm.edu/>

Tea Board, India <http://tea.nic.in/>
 The Horticultural Taxonomy Group <http://www.hortax.org.uk/>
 The International Society of Citriculture: http://www.lal.ufl.edu/isc_citrus_ho_mepage.htm
 The Internet Garden <http://www.internetgarden.co.uk/>
 The Rose Resource <http://rose.org/>
 The USDA Agricultural Research Service <http://www.ars.usda.gov/>
 University of Florida, Dept. of Environmental Horticulture <http://hort.ifas.ufl.edu/>
 University of California, Fruit&Nut Research <http://fruitsandnuts.ucdavis.edu/>
 USDA <http://www.usda.gov/>

Livestock Production Management

M.Sc. Programme

I Semester

Course No.	Course title	Credit hours
LPM 511	Cattle and buffalo production and management	3(2+1)
LPM 512	Sheep And Goat Production And Management	3(2+1)
LPM-513	Equine, swine and laboratory animal production and management	3(2+1)

II Semester

LPM 521	Shelter Management and Climatology	3(2+1)
LPM 522	Principles of environmental hygiene and waste management	3(3+0)
LPM 523	Poultry Farm and Hatchery Management	3(2+1)
LPM 524	Farm animal behaviour and wild life management and conservation	3(3+0)

III Semester

LPM 531	Integrated livestock farming system	3(2+1)
LPM 532	Livestock business management	3(2+1)

IV Semester

LPM 541	M.Sc. Seminar	1(0+1)
LPM 542	M.Sc. Comprehensive	2(0+2)
LPM 543	M.Sc. Research	15

LPM 511 Cattle and buffalo production and management 3(2+1)

Theory

Introduction-Development of dairy industry in India and world. Present status and future prospectus of livestock development in India, important breeds of cattle and buffalo, trait of economic importance and their inter-relationship- selection of high quality animals. Role of management in improving the reproduction efficiency in farm animals. Housing and rearing systems, breeding management. System of breeding. Economic traits Methods of breeding. Prenatal and post natal care and management of cattle and buffalo. Care of neonate and young calves. Management strategies for reducing mortality in calves, age at first calving and calving interval in cattle and buffaloes, management of labour. Milking management. machine milking and hand milking. Different laws governing the livestock sectors to produce quality products on par with international standards. Technique of harvesting clean and hygienic livestock products. Transportation of animals, health management. Wallowing in buffaloes. Management of draught animals and summer management, feed and fodder resources used for feeding of cattle and buffaloes. Scientific technique of feeding, watering. Computation of practical and economical ration, supply of green fodder around the year and enrichment of poor quality roughages,

Practical

Visit to cattle farms and critical analysis of various types of managerial practices. Study of breeding management in the farm. Analysis of practical feeding management. Disease control, housing, milking, calf, heifer and adult management. Dairy cattle and buffalo judging. Project preparation for external funding of commercial farms and enterprises for dairy products. Marketing strategies for milk, milk products and meat.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Introduction-Development of dairy industry in India & world.	1
2	Present & future prospectus of livestock development in India.	1
3	Important breeds of cattle.	1
4	Important breeds of cattle.	1
5	Important breeds of buffalo.	1
6	Trait of economic importance & their inter-relationship.	1
7	Selection of high quality animals.	1
8	Role of management in improving the reproduction efficiency in farm animals.	1
9	Housing & rearing systems of cattle & buffalo.	1
10	Housing & rearing systems of cattle & buffalo.	1
11	Breeding Management & system of breeding	1
12	Breeding Management & system of breeding	1
13	Economic traits Methods of breeding.	1
14	Prenatal & post natal care & Management of cattle & buffaloes.	1
15	Care of neonate & young calves.	1
16	Management strategies for reducing mortality in calves, age at first calving & calving interval in cattle & buffaloes	1
17	Management strategies for reducing mortality in calves, age at first calving & calving interval in cattle & buffaloes	1
18	Management of Labour.	1
19	Milking management, Hand & machine milking	1
20	Different laws governing the livestock sectors to products on par with international standards.	1
21	Techniques of harvesting clean & hygienic livestock products.	1
22	Health management.	1
23	Transportation of animals.	1
24	Wallowing in buffalo & summer management	1
25	Management of Draught animals	1
26	Feed & fodder resources used for feeding of cattle & buffaloes	1
27	Scientific techniques of feeding & watering.	1
28	Computation of practical & economic ration.	1
29	Computation of practical & economic ration.	1
30	Supply of green fodder around the year.	1
31	Enrichment of poor quality roughage	1

Lecture schedule- Practical

S. No	Title of Lecture	No. of lectures
1	Visit to cattle farms & Critical analysis of various types of managerial practices.	1
2	Study of breeding management in the farm.	1
3	Analysis of practical feeding management.	2
4	Housing management	1
5	Housing management	1
6	Disease control in dairy animals	1
7	Disease control in dairy animals	1
8	Calf, heifer & adult management.	1
9	Dairy cattle & buffalo judging.	1
10	Project preparation for external funding of commercial farms & Enterprises for dairy product.	2
11	Project preparation for external funding of commercial farms & Enterprises for dairy product.	1
12	Marketing for milk, milk products	2
13	Marketing for milk, milk products & meat.	1

Suggested Readings:

Arora SP.1997. Feeding of Dairy Cattle and Buffaloes. Kalyani.
Datta G.1994. Care and Management of Dairy Cattle and Buffaloes. 3rd Ed. ICAR
Thomas CK and Sastry,NSR.1991. Dairy Bovine Production. Kalyani.
Watson. 2012. Farm Animals and Their Management. Techno Books & Periodical

LPM 512**Sheep And Goat Production And Management****3(2+1)****Theory:**

Introduction. Population structure and importance. Advantages and disadvantages of sheep farming under different systems of management. Type of housing and equipments. Important sheep and goat breeds. Advantages and disadvantages of sheep and goat farming, breeding management: Breeding seasons, fitness of purchase for first breeding. Methods of detection of heat. Natural service and artificial insemination. Care of pregnant animals. Breeding stock. Use of teaser and culling, feeding management. Feeding methods. Principles to be followed in feeding and watering. Feeder and waterer space. Designing feeders and waterers. Range management. Stocking rate, pasture improvement and utilization. Management under stall fed conditions. Transportation of sheep and goat, disease management: Role of management in the prevention and control of diseases. Special management: Deworming, dipping spraying and shearing. Avoidance of goaty odour in milk, tugging, wool: importance of wool, fiber structure, fleece characters and goat fibers. Characters of mohair and pashmina, fur and Angora, marketing of goat fiber/wool. Planning of sheep and goat farm of various size. Economic of sheep and goat farming,

Practical:

Visit to sheep and goat farms and critical analysis of various managerial practices under different conditions. Study of practical housing management. Analysis of practical disease control management. Record keeping. Preparation of project for commercial farming. Characterisation of sheep and goat, handling of sheep and goat. Daily and periodical operations for sheep and goats. Methods of identification of sheep and goat. Cost of rearing sheep and goat for mutton and wool. Housing plans for various age and categories of sheep and goat. Dipping, vaccination of sheep and goat. Shearing of wool.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Introduction. Population structure and importance	1
2	Advantages and disadvantages of sheep farming under different systems of management	1
3	Type of housing and equipments.	2
4	Important sheep and goat breeds.	1
5	Advantages and disadvantages of sheep and goat farming	2
6	Breeding management: Breeding seasons, fitness of purchase for first breeding	2

7	Methods of detection of heat. Natural service and artificial insemination	2
8	Care of pregnant animals. Breeding stock. Use of teaser and culling.	2
9	Feeding management. Feeding methods. Designing feeders and waterers..	2
10	Principles to be followed in feeding and watering. Feeder and waterer space.	2
11	Range management. Stocking rate, pasture improvement and utilization	2
12	Management under stall fed conditions. Transportation of sheep and goat.	2
13	Disease management: Role of management in the prevention and control of diseases.	2
14	Special management: Deworming, dipping spraying and shearing.	2
15	Avoidance of goaty odour in milk, tugging.	1
16	Wool: importance of wool, fiber structure, fleece characters and goat fibers..	2
17	Economics of sheep and goat farming	2
18	Characters of mohair and pashmina, fur and Angora, marketing of goat fiber/wool.	1
19	Planning of sheep and goat farm of various size	1

Lecture schedule- Practical

S. No	Title of Lecture	No. of lectures
1	Visit to sheep and goat farms	1
2	Critical analysis of various managerial practices under different conditions	1
3	Study of practical housing management.	2
4	Analysis of practical disease control management	1
5	Record keeping. Preparation of project for commercial farming.	2
6	Characterisation of sheep and goat, handling of sheep and goat	2
7	Daily and periodical operations for sheep and goats	2
8	Methods of identification of sheep and goat.	1
9	Cost of rearing sheep and goat for mutton and wool	2
10	Housing plans for various age and categories of sheep and goat.	1
11	Dipping, vaccination of sheep and goat. Shearing of wool.	1

Suggested Readings:

Devendra C and Mecleroy GB 1982. Goat and Sheep Production in Tropics. Longman

Gupta, J L. 2006 Sheep Production and Management. B S Publication.

ICAR.2008. Hand Book of Animal Husbandry 3rd Ed.ICAR

Kaushish 1994. Sheep Production in the Tropics and Subtropics. Scientific publication.

Jindal. S. K.2012.Goat Production and Health Management.New India Pub Agency.

LPM-513 Equine, swine and laboratory animal production and management 3(2+1)

Theory:

Introduction. Population and importance. Economic contribution of pigs and equine. Advantages and disadvantage of swine and equine keeping. Systems of management. Problems in equine and pig farming, breeds of swine and equine. Selection of breeding stocks. Breeding season. Age and weight at first services. Methods of detection of heat. Natural service and AI. Care of pregnant animals, young ones and growing stock. Care of breeding males, sanitation and hygiene, disease prevention measures. Housing and equipments. Wallowing. Role of management in the prevention and the control of diseases, feeding and management of new born, weaner, finishers, dry, pregnant and farrowing and foaling. Feeding principles to be followed. Methods of watering. Feeder and waterer space. Record keeping, importance of rabbit for meat and fur production. Common breeds of rabbit, rat, mice and guinea pig. Breeding, feeding and management of laboratory animals. System of housing. Common diseases and their control measure. Marketing of meat and fur.

Practical:

Visits to pig, stud and laboratory animal farms. Critical analysis of various types of managerial practices. Analysis of practical breeding management methods and disease control management of pig, equine and laboratory animals.

Aging and identification, Judging. Practical care and management at parturition. Economics of production. Project preparation for research and commercial farms.

Lecture schedule-Theory

S. No	Title of Lecture	No. of lectures
1	Economic contribution of pigs and equine	1
2	Advantages and disadvantage of swine and equine keeping	1
3	Systems of management	1
4	Problems in equine and pig farming	1
5	Economic contribution of pigs and equine	1
6	Breeds of swine and equine.	1
7	Selection of breeding stocks	1
8	Breeding season. Age and weight at first services.	1
9	Methods of detection of heat.	1
10	Natural service and AI	1
11	Care of pregnant animals, young ones and growing stock	1
12	Care of breeding males	1
13	Sanitation and hygiene	1
14	Disease prevention measures	1
15	Housing, equipments and wallowing	1
16	Role of management in the prevention and control of diseases	2
17	Feeding & management of new born, weaner, finishers, dry and pregnant	2
18	Farrowing and foaling	1
19	Feeding principles to be followed	1
20	Methods of watering, Feeder and waterer space	1
21	Record keeping	1
22	Importance of rabbit for meat and fur production	1
23	Common breeds of rabbit,rat,mice and guinea pig	1
24	Breeding,feeding and management of laboratory animals	2
25	System of housing	1
26	Common diseases and their control measure	2
27	Marketing of meat and fur	1

Lecture schedule- Practical

S.No.	Topic	No. of lectures
1	Visits to pig, stud and laboratory animal farms	1
2	Critical analysis of various types of managerial practices	2
3	Analysis of practical breeding management methods	2
4	Disease control management of pig	1
5	Disease control management of equine	1
6	Disease control management of laboratory animals	2
7	Aging and identification	1
8	Judging	1
9	Practical care and management at parturition	1
10	Economics of production	2
11	Project preparation for research and commercial farm	2

Suggested Readings

- Boden, S.1995. Swine Practices. W B London.
 Narayankhedkar, SG. 1997. Production and Management of Swine, Camel, Equine and Yak. Tindall Pub.
 Ronald N and Penman S. 1991. A Manual for Small Scale Rabbit Production.South Asia Publication.
 Dimri,U, Sharma,M C and Tiwari R.2013.Swine Production and Health Management.New India Pub Agency.
 Reddy, D V 2007. Applied Nutrition (Livestock,Poultry,Human,Pet,Rabbit and Laboratory animals) IBH,Oxford.
 Rajeshwari,YB .2009.Handbook on Care and Management of Laboratory and Pet Animals. New India Pub Agency

LPM 521**Shelter Management and Climatology****3(2+1)****Theory:**

General principles in planning animal houses. Farmstead and animal houses. Selection of site and planning, layouts for livestock farm of different sizes in different climatic zones in India. Farm structures. General principles of construction of enclosures, floor and road, housing requirements of different classes of Livestock. Preparation of layouts, plans, arrangement of alleys. Fitting and facilities in the houses for dairy cattle, calves, bulls, bullocks, sheep, goat and poultry, improvement of existing buildings, water supply, feed and fodder delivery systems. Economics of livestock housing, Disease control measures and sanitation of all classes of livestock, definition of climate. Classification of climatic regions. Climatic factors. Assessment of climate. Study of climatic factors in relation to animal production. Estimation of microclimatic conditions in animal house. Measurement of temperature, relative humidity, air velocity and mean temperature of the surrounding, measurement of intensity of light in animal houses. Construction of climographs and hythergraphs. Estimation of cooling power of atmosphere, heat tolerance test in bovines. Microclimate modification in animal house. Importance of light in animal production.

Practical:

Score card for animal houses. Time and motion study in animal houses. Preparation of plans for animal houses for cattle, sheep, pigs, goats and other livestock. Economics of livestock housing. Preparation of plan for animal houses of different sizes and climatic zones of India.

Lecture schedule- Theory

S. No	Topic	No. of lectures
1	Shelter management & Its importance.	1
2	General principles in planning animal houses.	1
3	Animal houses & Farmstead: - Selection of site & planning.	1
4	Layouts for Livestock farm of different sizes in different climatic zones in India.	1
5	Farm Structures:- General principles of construction of enclosures, floor & road.	1
6	General principles of construction of enclosures, floor & road.	1
7	Housing requirements of different classes of Livestock.	1
8	Preparation of layouts, plans, arrangement of alleys.	1
9	Cattle & Buffalo Housing:-Fitting & facilities in the houses for dairy cattle, calves, bulls & bullocks.	1
10	Sheep Housing:- Fitting & facilities in the houses for sheep	1
11	Goat Housing:-Fitting & facilities in the houses for goat.	1
12	Poultry Housing:-Fitting & facilities in the houses for poultry.	1
13	Improvement of existing building.	1
14	Water supply systems in the animal housing.	1
15	Feed &Fodder delivery systems in the animal housing.	1
16	Economics of Livestock housing.	1
17	Economics of Livestock housing.	1
18	Disease control measures & Sanitation of all classes of livestock.	1
19	Disease control measures & Sanitation of all classes of livestock.	1
20	Importance of light in animal production.	1
21	Definition of climate.	1
22	Classification of climatic regions.	1
23	Climatic factors.	1
24	Assessment of climate.	1
25	Study of climatic factors in relation to animal production.	1
26	Estimation of microclimatic conditions in animal house.	1
27	Measurement of temperature & relative humidity.	1
28	Measurement of air velocity & mean temperature of surrounding.	1
29	Measurement of intensity of light in animal houses.	1

30	Construction of climographs & hythergraphs.	1
31	Estimation of cooling power of atmosphere.	1
32	Microclimate modification in animal house.	1

Lecture schedule- Practical

S. No	Topic	No. of lectures
1	Introduce to Shelter management & Visit of dairy farm.	1
2	Lay out of 100 cows at the modern dairy farm.	1
3	Comparison of different houses for livestock.	1
4	Score card for Dairy cattle Judging.	1
5	Time & motion study in animal houses.	1
6	Preparation of plans for animal houses for cattle	1
7	Preparation of plans for animal houses for cattle	1
8	Preparation of plans for animal houses for sheep	1
9	Preparation of plans for animal houses for Goats	1
10	Preparation of plans for animal houses for Pigs Equine, Camel & Poultry	1
11	Economics of Livestock housing.	1
12	Economics of Livestock housing	1
13	Score card for animal houses .	1
14	Preparation of plan for animal houses of different sizes	1
15	Climatic zone of India.	1
16	Animal housing system in different Climatic zone of India.	1

Suggested Reading:

Sastry N S R and Thomas, C K 2006. Livestock Production and Management. Kalyani
 Thomas, C K and Sastry, NSR 1991. Dairy Bovine Production. Kalyani.
 Wathes, C M and Charles, D R 1994. Livestock Housing. CABI.
 Lal, D S 1998. Climatology. Sharda Pustak Bhawan, Allahabad.
 McDowell, R E. 1972. Improvement of Livestock Production in Warm Climates. W H Freeman.
 Siddhartha K and Roger, B 1996. Atmosphere, Weather and Climate. ELBS.

LPM 522 Principles of environmental hygiene and waste management 3(3+0)

Theory:

Animal air hygiene. Definition. Composition of air. Air pollution. Factors affecting outdoor and indoor pollution. Effect of assessment of these factors on animal health and production. Methods to control these factors, water hygiene. Importance of water. Impurities and inclusions. Sterilization. Examination of water and water supplies. Collection of samples. Topographical, physical, chemical, bacteriological and microscopic examination of water. Hygienic requirements and standards for drinking water. Quantity of water required by domestic animals. Methods of watering, manure. Quantity of manure voided by domestic animals. Animal excreta a factor in spread of disease. Hygienic and economic disposal of farm waste. Modern techniques used in automation/semi-automation in disposal of farm waste, environmental protection act. Air (Prevention and control of pollution) act and water (Prevention and control of pollution) act. Biosecurity measures to be adapted for efficient and healthy production, effect of environmental pollution on livestock and its products directly and indirectly. Controlling environmental pollution. Different factors affecting the quality of livestock and its products meant for human consumption.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Animal air hygiene. Definition. Composition of air. Air pollution.	2
2	Factors affecting outdoor and indoor pollution.	3
3	Effect of assessment of these factors on animal health and production. Methods to control these factors	5
4	Water hygiene. Importance of water. Impurities and inclusions. Sterilization. Examination of water and water supplies	4

5	Collection of samples. Topographical, physical, chemical, bacteriological and microscopic examination of water	4
6	Hygienic requirements and standards for drinking water. Quantity of water required by domestic animals. Methods of watering	5
7	Manure. Quantity of manure voided by domestic animals.	3
8	Animal excreta a factor in spread of disease. Hygienic and economic disposal of farm waste.	3
9	Modern techniques used in automation/semi-automation in disposal of farm waste.	3
10	Environmental protection act	2
11	Air(Prevention and control of pollution) act and water(Prevention and control of pollution)act	3
12	Biosecurity measures to be adapted for efficient and healthy production.	2
13	Effect of environmental pollution on livestock and its products directly and indirectly.	3
14	Controlling environmental pollution.	3
15	Different factors affecting the quality of livestock and its products meant for human consumption.	3

Suggested Readings:

Baba, MD 2007. Environmental Changes and Natural Disaster. New India Pub.

Overcash, M R 1983. Livestock Waste Management. CRC Press.

Thapliyal, D C and Mishra, D S.1996. Fundamental of Animal Hygiene and Epidemiology. International Book Dist.Co.

LPM 523 Poultry Farm and Hatchery Management

3(2+1)

Theory:

Poultry housing system. CageVs floor system. Litter management and lights for poultry, rearing turkey,duck and quails, management of chicks,growing,laying and breeding flocks, broiler production,selection and culling of laying flocks, procuring, care and preincubation storage of hatching eggs. Methods of incubation,sanitation disinfection and management of hatchery, embryonic development and factors affecting fertility and hatchability of eggs. Chick sexing, packing and hatchery business. Transporting management of farm and hatchery products and waste.

Practical:

Poultry farm management. Brooding of chicks, selection of laying flocks. Disease preventive measures. Selection and care of hatching eggs, incubator operation,fumigation, candling, setting and hatching. Packaging of chicks. Waste management. Marketing of products.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Poultry housing system	2
2	CageVs floor system.	2
3	Litter management and lights for poultry	2
4	Rearing turkey,duck and quails	2
5	Management of chicks,growing,laying and breeding flock	2
6	Broiler production	3
7	Selection and culling of laying flocks	2
8	Procuring, care and preincubation storage of hatching eggs	3
9	Methods of incubation,sanitation, disinfection and management of hatchery	4
10	Embryonic development	2
11	Factors affecting fertility and hatchability of eggs.	2
12	Chick sexing	1
13	Packing of chicks	1
14	Hatchery business	2
15	Transporting management of farm and hatchery products and waste.	2

Lecture schedule- Practical

S. No	Topic	No. of lectures
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1	Poultry farm management	1
2	Brooding of chicks	1
3	Selection of laying flocks	1
4	Disease preventive measures	2
5	Selection and care of hatching eggs	1
6	Incubator operation	2
7	Fumigation	1
8	Candling	1
9	Setting of eggs hatching	1
10	Selection and care of hatching eggs	2
11	Packaging of chicks	1
12	Waste management	1
13	Marketing of products	1

Suggested Readings:

Ensminger,ME.1992. Poultry Science. International Book Dist Co.
Hued, L M. 2003. Modern Poultry Farming. Greenworld.
Powell-Owen.W. 2008. Poultry Farming and Keeping. Daya Books.
Prashad J. 2005. Poultry Production and Management. Kalyani.
Singh,R A.1996. Poultry Production 3rd Ed Kalyani.
Nandi,S. 2012. Poultry Diseases. : At a Glance. Vardhman Books & Periodicals

LPM 524 Farm animal behaviour and wild life management and conservation 3(3+0)

Theory

Introduction to animal behaviour Importance of animal behavior studies,pattern of behavior. Daily and seasonal cycles of behavior. Physiological basis of behaviour, environmental modification of behavior. Developmental changes in behavior. Genetic differences in behavior. Behavioural disorders, group formation.Social relationship, process of socialization, locality and behavior. Practical application. Behavioural character for managerial practice. Favourable and unfavourable behavior for domestication. Behavioural adaptations under domestication, physical environment and behavior. Common vices and their remedial measures. Analysis of behavior in relation to location. Analysis of behavior in relation to climatic environment. Analysis of social behaviour, principles and concept . Ecology of wildlife sanctuaries and national parks. Biological and ecological basis of management of wild animals. Wild life protection act. Record keeping. Breeding season pregnancies, parturition,lactation in wild life animals.

Lecture schedule- Theory

S. No	Topic	No. of lectures
1	Introduction to animal behaviour Importance of animal behavior studies,pattern of behavior.	2
2	Daily and seasonal cycles of behavior. Physiological basis of behavior.	3
3	Environmental modification of behavior.	5
4	Developmental changes in behavior. Genetic differences in behavior.	4
5	Behavioural disorders.	3
6	Group formation.Social relationship, process of socialization, locality and behavior	3
7	Practical application. Behavioural character for managerial practice	2
8	Favourable and unfavourable behavior for domestication.	2
9	Behavioural adaptations under domestication	2
10	Physical environment and behavior	2
11	Common vices and their remedial measures	2
12	Analysis of behavior in relation to location.	3
13	Analysis of behavior in relation to climatic environment	3
14	Analysis of social behavior.	2
15	Principles and concept . Ecology of wildlife sanctuaries and national parks.	3

16	Biological and ecological basis of management of wild animals.	2
17	Wild life protection act. Record keeping.	3

Suggested Readings:

Arora MP.1995. Animal Behaviour. WB London.
 Fraser A F and Broom D M 1997. Farm Animal Behavior and Welfare. CABI.
 Kumar,V.1996. Animal Behaviour. WB London
 Bobbins C T 1983. Wildlife Feeding and Nutrition. Daya Pub. House
 Giles, RH.1978. Wildlife Management. Wild Life Society.
 Giles,RH.1984. Wildlife Management Techniques 3rd Ed. Wild Life Society.
 WWF.1994 Wild Life Protection Act 1972.(as amended upto 1991) Natraj Pub.
 Jadhav,N V,Baig, M I and Devangare,A A 2004. Handbook of Wild Animals and Livestock Management.

LPM 531 Integrated livestock farming system 3(2+1)

Theory:

Scope and limitation of integrated farming systems. Sustainability of integrated Livestock Farming Systems and their economic importance, integration of fish,arable farming and different livestock enterprises vis-à-vis gobar gas plant. FYM, solar and wind energy utilization,cattle, buffalo,sheep,goat,pig,poultry,rabbit,silk worm and beekeeping etc., new approach for changing farming systems in present energy crisis, project formulation and evaluation of various livestock enterprises.

Practical:

Various livestock farming units and their economic analysis. Evaluation of different farming systems and their economic importance. Preparing feasibility report for various farming projects.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Scope and limitation of integrated farming systems	4
2	Sustainability of integrated Farming systems and their economic importance	3
3	Integration of fish, arable farming and different livestock enterprises vis-à-vis gobar gas plant	7
4	FYM	1
5	Solar energy	1
6	Wind energy utilisation	1
7	Cattle, buffalo, sheep, goat, pig, poultry, rabbit, silkworm and beekeeping	5
8	New approach for changing farming systems in present energy crisis	5
9	Project formulation and evaluation of various livestock enterprises	5

Lecture schedule- Practical

S. No	Title of Lecture	No. of lectures
1	Various livestock farming units and their economic analysis	4
2	Evaluation of different farming systems and their economic importance	5
3	Preparing feasibility report for various farming project	7

Suggested Readings:

Mukherjee T K .1992. Integrated Livestock Fish Production Systems
 Raman K V and Balaguru. T(Eds)1992. Farming systems research in India: Strategies for Implementation. NAARM
 Renard, C(Ed.)1997. Crop Residues in Sustainable Mixed Crop/Livestock Farming system.CABI.
 Speirs M and Opsen,O. 1992. Indigenous Integrated Farming System in the Sahel. World Bank.

LPM 532 Livestock business management 3(2+1)

Theory:

Management principles. Planning, techniques, strategic planning, organization structure, co-ordination and controlling techniques. Approaches to management, SWOT analysis, financial accounting. Accounting records. Balance sheet. Fund Flow statement. Cost and analysis for managerial decisions. Budgeting and control, tools of financial analysis. Working capital financing. Long term financial management. Investment analysis. Capital markets. Corporate risk management. Venture capital, marketing. Objective strategies. Selecting managing marketing channels. Pricing strategies. Sales promotion. Legislation relating licensing. Company laws.

Practical:

Preparation of financial statements, depreciation accounting methods trend and variance analysis, cost volume profit analysis. Financial planning and forecasting. Estimation of working capital requirement. Break even analysis. Visit to livestock business firms and banks. Preparing projects for financing.

Lecture schedule- Theory

S. No	Title of Lecture	No. of lectures
1	Management principles and planning techniques	2
2	Strategic planning	2
3	Organisation structure	2
4	Coordination and controlling techniques	3
5	Approaches to management	2
6	SWOT analysis	1
7	Financial accounting.	2
8	Accounting records.	1
9	Balance sheet. Fund Flow statement.	2
10	Cost and analysis for managerial decisions. Budgeting and control.	2
11	Tools of financial analysis.	2
12	Working capital financing	1
13	Long term financial management.	2
14	Investment analysis.	1
15	Capital markets..	1
16	Corporate risk management. Venture capital	1
17	Marketing. Objective strategies. Selecting managing marketing channels.	2
18	Pricing strategies. Sales promotion.	1
19	Legislation relating licensing. Company laws.	2

Lecture schedule- Practical

S. No	Title of Lecture	No. of lectures
1	Preparation of financial statements	2
2	Depreciation accounting methods trend and variance analysis	2
3	Cost volume profit analysis	2
4	Financial planning and forecasting	2
5	Estimating of working capital requirement	2
6	Break even analysis	2
7	Visit to livestock business firm and banks	2
8	Preparing projects for financing	2

Suggested Readings.

- Koontz H and O'Donnel, C.1999. Essentials of Management. Tata McGraw Hill.
 Totler P.2000 Marketing Management. Analysis, Planning and Control. Prentice Hall of India.
 Maheshwari, SN.1998. Management Accounting. Tata McGraw Hill
 Massie, J L 1995. Essential of Management. Prentice Hall of India
 Gangadhar, K S.2009. Livestock Economics, Marketing Business Management and Accountancy. New India Pub Agency
 Bardhan.2012. Textbook on Livestock Economics Marketing and Business Management. Techno Books & Periodicals

NEMATOTOLOGY

M.Sc.Ag.

CODE	COURSE TITLE	CREDITS
NEMAT 511	Principles of Nematology	2+1
NEMAT 521	Nematode diseases of crops	2+1
NEMAT 531	Nematode management	2+1

NEMA 511

Principles of Nematology

3(2+1)

Objective-

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory-

History and growth of nematology; nematode habitats and diversity, plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry. Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology. Types of parasitism, nature of damage and general symptomatology; interaction of plant parasitic nematodes with other organism, Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes. Principles and practices of nematode management; integrated nematode management.

Practical-

Studies on kinds of nematodes-free living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining of sedentary endoparasites; examination of different life stages of important plant parasitic nematodes; their symptoms and histopathology.

Lecture schedule- Theory

S.No.	Topic	No. of lectures
1	History and growth of nematology; nematode habitats and diversity, plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.	4
2	Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.	12
3	Types of parasitism, nature of damage and general symptomatology; interaction of plant parasitic nematodes with other organism.	7
4	Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.	4
5	Principles and practices of nematode management; integrated nematode management.	5

Lecture schedule- Practical

S. No.	Topics	No. of lectures
1	Studies on kinds of nematodes-free living, animal, insect and plant parasites	2
2	Nematode extraction from soil; extraction of migratory endoparasites	3
3	Staining of sedentary endoparasites	1
4	Examination of different life stages of important plant parasitic nematodes; their symptoms and histopathology.	10

Suggested Readings-

Dropkin VH. 1980, *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
 Perry RN & Sitaramaiah K. 1994. *Plant Pathogens-Nematodes*. Oxford & IBH, New Delhi.
 Thorne, G.1961.*Principles of Nematology*. McGraw Hill, New Delhi.
 Walia RK & Bajaj HK.2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

NEMA 521**Nematode Diseases of Crops****3(2+1)****Objective**

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops. Cereal crops-Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum. Pulses, sugar, fibre, fodder and oilseed crops-pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugar beet cyst and soybean cyst nematode problems. Vegetable crops-root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation. Fruit crops-root-knot disease, reniform nematode, slow decline of citrus, mushroom-nematode problems. Plantation, medicinal and aromatic crops-burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems coffee and tea, red ring disease of coconut. Forest-pines wilt disease.

Practical-

Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops/ field diagnosis of nematode problems.

Lecture schedule :Theory

S.No.	Topics	No. of lectures
1	Cereal crops-Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.	7
2	Pulses, sugar, fibre, fodder and oilseed crops-pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugar beet cyst and soybean cyst nematode problems.	7
3	Vegetable crops-root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.	6
4	Fruit crops-root-knot disease, reniform nematode, slow decline of citrus, mushroom-nematode problems.	6
5	Plantation, medicinal and aromatic crops-burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems coffee and tea, red ring disease of coconut. Forest-pines wilt disease.	6

Lecture schedule: Practical

S. No.	Topics	No. of lectures
1	Diagnosis of causal organisms	6
2	Identification of different life cycle stages	6
3	Study of symptoms and histopathology of nematode damage in different crops	2
4	Diagnosis of nematode problems.	2

Suggested Readings-

Bhatti DS & Walia RK. 1992. *Nematode Pest of Crops*. CBS New Delhi.

- Evans AAF, Trudgill DL & Webster JM. 1994. *Plant Parasitic Nematodes in Temperate Agriculture*. CABI, Wallingford
- Luc M, Sikora RA & Bridge J. 2005. *Plant Parasitic Nematodes in Sub-Tropical and Tropical Agriculture*. CABI, Wallingford.
- Nickle WR, 1991. *Manual of Agricultural Nematology*. Marcel Dekker, New York.
- Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.

NEMA 531

Nematode Management

3(2+1)

Objective

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis. Chemical methods-nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use. Cultural practices-crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil; antagonistic and trap crops, sanitation etc. physical methods-use of heat, hot water treatment and other methods of disinfections of plant material. Biological methods-concept and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods-use of antagonistic plants and antinemic plant products. Genetic methods-plant resistance; legal methods-quarantine regulations; integrated nematode management-concepts and applications.

Practical-

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on bio control potential of fungal, bacterial parasites, and predacious fungi and nematodes.

Lecture schedule: Theory

S. No.	Topics	No. of lectures
1	Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.	5
2	Chemical methods-nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.	8
3	Cultural practices-crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil; antagonistic and trap crops, sanitation etc. physical methods-use of heat, hot water treatment and other methods of disinfections of plant material	7
4	Biological methods-concept and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods-use of antagonistic plants and anti-nemic plant products.	6
5	Genetic methods-plant resistance; legal methods-quarantine regulations; integrated nematode management-concepts and applications.	6

Lecture schedule: Practical

S. No.	Topics	No. of lectures
1	In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods	4
2	Methods for screening of crop germplasm for resistance against nematodes	6
3	Laboratory exercises on bio control potential of fungal, bacterial parasites, predacious fungi and nematodes.	6

Suggested Readings

- Bhatt DS & Walia RK. 1994. *Nematode Pest Management in Crops*. CBS, New Delhi.
- Brown RH & Kerry BR. 1987. *Principles and Practices of Nematode Control in crops*. Academic Press, Sydney.
- Chen ZX, Chen SY & Dickson DW. 2004. *Nematology: Advances and Perspectives. Vol. II: Nematode Management and Utilization*. CABI, Wallingford.
- Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.
- Starr JL, Cook R & Bridge J. 2002. *Plant Resistance to Parasitic Nematodes*. CABI, Wallingford.
- Whitehead AG. 1997. *Plant Nematode Control*, CABI, Wallingford.

List of Journals

- Annals of Applied Nematology* - Society of Nematologists, USA
- Current Nematology* - Bioved Research Society, Allahabad, India
- Egyptian Journal of Agronomatology* – Egyptian Society of Agricultural Nematology
- Indian Journal of Nematology* - Nematological Society of India
- International Journal of Nematology* - Afro-Asian Society of Nematologists, Luton
- Japanese Journal of Nematology* - Japanese Nematological Society
- Journal of Nematology* - Society of Nematologists, USA
- Journal of Nematode Morphology and Systematics* –Jaen, Universidad de Jaen
- Nematologia Brasileira* – Brazilian Nematological Society
- Nematologia Mediterranea* – Istituto per la Protezione delle Plante (IPP) – Sect. of Bari of the CNR, Italy
- Nematology* - Brill Academic Publishers, UK
- Nematropica* - Organization of Nematologists of Tropical America
- Pakistan Journal of Nematology* - Pakistan Society of Nematologists
- Russian Journal of Nematology* - Russian Society of Nematologists

e-Resources

- <http://www.nematologists.org/> (The Society of Nematologists)
- <http://nematology.ucdavis.edu/> (Deptt. of Nematology, Univ. of California, Davis)
- <http://www.ifns.org/> (International Federation of Nematology Societies)
- <http://www.inaav.ba.cnr.it/nemmed.html> (Nematologia Mediterranea)
- <http://nematode.unl.edu/Nemajob.htm> (Nematology Employment Bulletin Board)
- <http://nematode.unl.edu/> (University of Nebraska - Lincoln Nematology)
- <http://nematode.unl.edu/wormsite.htm> (Links to Other Nematology Resources)
- <http://nematode.unl.edu/SON/jon.htm> (Journal of Nematology)
- <http://www.nematology.ucr.edu/> (Deptt. of Nematology, Univ. of California, Riverside)
- <http://entnemdept.ifas.ufl.edu/> (Univ. of Florida, Entomology & Nematology Dept.)
- http://www.brill.nl/m_catalogue_sub6_id8548.htm (Nematology - journal)
- http://www.ars.usda.gov/main/site_main.htm?modecode=12752900 (Nematology Lab., USDA)
- http://flnem.ifas.ufl.edu/HISTORY/nem_history.htm (Nematology history)
- <http://www.nematology.ugent.be/> (Nematology Unit, Ghent University)
- <http://www.entm.purdue.edu/nematology/> (The Purdue Nematology Lab.)
- <http://www.bspp.org.uk/ppigb/nematolo.htm#a-z> (Links to Nematology labs)
- <http://www.nem.wur.nl/UK/> (Laboratory of Nematology, Wageningen Univ.)
- <http://onta.ifas.ufl.edu/> (The Organization of Nematologists of Tropical America)
- <http://nematology.umd.edu/nematology.html> (Plant Nematology Laboratory, Maryland)
- <http://www.biology.leeds.ac.uk/nem/> (Plant Nematology Lab., University of Leeds)
- <http://www.plantpath.iastate.edu/dept/labs/tylka/> (Iowa State University, Nematology Lab)
- <http://nematologists.org.au/newsletters.html> (Australasian Association of Nematologists)
- <http://soilplantlab.missouri.edu/nematode/> (Plant Nematology Laboratory, Missouri)
- <http://www.eumaine.ugent.be/> (European Master of Science in Nematology)
- <http://www.jstage.jst.go.jp/browse/jjn> (The Japanese Journal of Nematology)

PLANT BREEDING AND GENETICS

List of courses offered in M.Sc. Ag degree programme :

I Semester		
PBG 511*	Principles of Genetics and Cell Biology	2+1
PBG 512*	Principles of Plant Breeding	2+1
PBG 513	Molecular Genetics	3+0
II Semester		
PBG 521	Plant Genetic Resources and Seed Technology	2+1
PBG 522*	Principles of Quantitative Genetics	2+1
PBG 523*	Biotechnology for crop improvement	2+1
PBG 524	Principles of Cytogenetics	2+1
III Semester		
PBG 531	Mutagenesis and Mutation Breeding	2+1
PBG 532	Heterosis Breeding	2+1
IV Semester		
PBG 541	Seminar	0+1
PBG 542	Comprehensive	0+2
PBG 543	Masters' Research	15

List of courses offered in Ph.D. degree programme

I Semester		
PBG 612*	Advanced Genetics	3+0
PBG 614	Advances Biometrical and Quantitative Genetics	2+1
II Semester		
PBG 621*	Genetic Engineering	2+1
PBG 624	Breeding Designer Crops	2+1
III Semester		
PBG 641	Doctoral Seminar	0+ 2
PBG 642	Preliminary	0 +4
PBG 643	Doctoral Research	40

- Core courses

Objective

This course is aimed at understanding the basic concepts of genetics, and cell biology helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

Principles of Genetics: Beginning of genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

Multiple alleles, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes. Crossing over-mechanisms and theories of crossing over- recombination models, cytological basis. Somatic cell genetics, Extra chromosomal inheritance, Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioral genetics.

Cell Biology: Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids-chloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes, Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes. Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition.

Practical

Numericals related to Mendel's laws, gene interaction, linkage and construction of genetic maps. Polygenic inheritance. Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; Principles of microscopy: phase contrast, autoradiography and electron microscopy. Differential centrifugation for isolating macroscopic components. Preparation and use of different killing and fixation reagents used in cytological studies. Preparation of important stains like aceto caramine, aceto orcin and fuelgen stain. Exercises related cell division- mitosis and meiosis.

Lecture schedule : Theory

S. No.	Topic	No. of Lectures
1	Beginning of genetics; Early concepts of inheritance,	1
2	Mendel's laws; and discussion on Mendel's paper,	1
3	Chromosomal theory of inheritance	1
4	Multiple alleles	1
5	Gene interactions. I	1
6	Gene interactions. II	1
7	Sex determination and Differentiation	1
8	Sex-linkage	1
9	Sex linked, Sex-influenced and sex-limited traits	1
10	Detection and Estimation of linkage	1
11	Recombination and genetic mapping in eukaryotes	1
12	Crossing over and its mechanisms	1
13	Theories of crossing over- recombination models	1
14	Cytological basis of crossing over	1
15	Somatic cell genetics	1
16	Extra chromosomal inheritance	1
17	Concepts of Eugenics and Epigenetics	1
18	Genetic disorders and Behavioral genetics	1
19	Cell, its ultrastructures, differences between eukaryotic and prokaryotic cells	1
20	Macromolecules of cell	1
21	Structure and function of cell wall, nuclear membrane and plasma membrane	1
22	Cellular Organelles – nucleus,	1
23	Cellular Organelles – plastids- chloroplasts and chromoplast	1
24	Cellular Organelles- endoplasmic reticulum,	1

25	Cellular Organelles - Golgi complex, lysosomes, peroxisomes.	1
26	Cell Cycle and cell division – mitosis	1
27	Cell division- meiosis, synapsis, structure and function of synaptonemal complex	1
28	Differences, significance and deviations in cell divisions	1
29	Spindle apparatus, anaphase movement of chromosomes.	1
30	Bioenergetics; Ultrastructure and function of mitochondria and biological membranes	1
31	Chloroplast and other photosynthetic organelles	1
32	Interphase nucleus- Structure and chemical composition.	1

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1	Numericals related to Mendel's laws,	1
2	Numericals related to gene interaction	1
3	Laboratory exercises in probability and chi-square	1
4	Numericals related to linkage and construction of genetic maps.	1
5	Chromosome mapping using three point test cross	1
6	Tetrad analysis	1
7	Demonstration of genetic principles using laboratory organisms	1
8	Induction and detection of mutations through genetic tests	1
9	Principles of microscopy: parts of a microscope and their functions, types	1
10	Phase contrast microscopy	1
11	Autoradiography and Electron microscopy.	1
12	Differential centrifugation for isolating macroscopic components	1
13	Preparation and use of different killing and fixation reagents used in cytological studies.	1
14	Preparation of important stains like aceto caramine, aceto orcin and fuelgen stain.	1
15	Exercises related cell division- mitosis	1
16	Exercises related cell division- meiosis.	1

Suggested Readings :

- B.D.Singh. 2005. Genetics. Kalyani Publishers, Ludhiana.
 Gardner EJ, Simmons, M J and Snustad DP. 1991. Principles of Genetics. John Wiley & Sons
 Karp G. 2008. Cell and Molecular Biology: Concepts and Experiments. John Wiley and Sons.
 Klug WS & Cummings MR. 2003. Concepts of Genetics. Peterson Edu.
 Lewin B. 2008. Genes IX. Jones & Bartlett Publ.
 P.K.Gupta. 2006. Cell Biology, Rastogi Publications.
 Russell PJ. 1998. Genetics. The Benzamin/Cummings Publ. Co.
 Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons.
 Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India
 Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs.
 Uppal S, Yadav R, Subhadra & Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

PBG 512

Principles of Plant Breeding

3(2+1)

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory :

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance, genetic basis of breeding self- and cross -pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype-environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role

of plant genetic resources in plant breeding, pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach), breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds, breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection, self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding, special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

Practical :

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1	Introduction and History of Plant Breeding (Pre and post-Mendelian era)	1
2	Objectives of plant breeding, characteristics improved by plant breeding	1
3	Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.	1
4	Genetic basis of breeding self- and cross -pollinated crops	1
5	Mating systems and response to selection	1
6	Nature of variability, components of variation, heritability and genetic advance	1
7	Genotype-environment interaction	1
8	Combining ability: Introduction and types (General and specific combining ability,	1
9	Types of gene actions and implications in plant breeding	1
10	Plant introduction and role of plant genetic resources in plant breeding.	1
11	Breeding methods in self pollinated crops, Pure line theory & Pure line selection	1
12	Mass selection methods	1
13	Line breeding Method, Pedigree Method	1
14	Bulk Method and Single seed descent Method	1
15	Backcross Method	1
16	Multiline method	1
17	Population breeding in self-pollinated crops (diallel selective mating approach)	1
18	Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods	1
19	S1 and S2 progeny testing, progeny selection schemes	1
20	Recurrent selection schemes for intra and inter- population improvement I	1
21	Recurrent selection schemes for intra and inter- population improvement II	1
22	Development of synthetics and composites	1
23	Hybrid breeding - genetical and physiological basis of heterosis and inbreeding	1
24	Production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance	1
25	Seed production of hybrid and their parent varieties/inbreds.	1
26	Breeding methods in asexually/clonally propagated crops, clonal selection and apomixes,	1
27	Male sterility in crop plants and their commercial exploitation	1
28	Self-incompatibility in crop plants and their commercial exploitation	1
29	Concept of plant ideotype and its role in crop improvement	1
30	Transgressive breeding	1
31	Mutation breeding	1
32	Breeding for abiotic and biotic stresses	1

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1	Floral biology of important crops of the locality. I	1
2	Floral biology of important crops of the locality. II	1
3	Emasculation, selfing and crossing techniques.	1
4	Floral biology in self pollinated species I	1
5	Floral biology in self pollinated species II	1
6	Floral biology in cross pollinated species I	1
7	Floral biology in cross pollinated species II	1
8	Selection methods in segregating populations and evaluation of breeding material	1
9	Observation recording	1
10	Analysis of variance (ANOVA) through RBD	1
11	Analysis of variance (ANOVA) through LSD	1
12	Estimation of components of variance, heritability and genetic advance	1
13	Maintenance of experimental records	1
14	Learning techniques in hybrid seed production using male-sterility in field crops (pearlmillet)	1
15	Learning techniques in hybrid seed production using male-sterility in field crops (sorghum)	1
16	Learning techniques in hybrid seed production using male-sterility in field crops (Maize)	1

Suggested Readings :

- Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
 Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.
 Chopra VL. 2004. Plant Breeding. Oxford & IBH.
 Gupta SK. 2005. Practical Plant Breeding. Agribios. Jodhpur
 Pohlman JM & Bothakur DN. 1972. Breeding Asian Field Crops. Oxford & IBH.
 Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
 Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
 Simmonds NW. 1990. Principles of Crop Improvement. English Language Book Society.
 Dana, Sukumar. 2001. Plant Breeding. Naya Udyog, Colcutta. 700 006
 Kucku, Kobabe and Wenzel (1995). Fundamentals of Plant Breeding. Narosa Publishing House, New Delhi
 Singh BD. 2006. Plant Breeding. Kalyani. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani.
 Singh P. 2006. Essentials of Plant Breeding. Kalyani.
 Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.
 Stoskopf, N C, Tomes, D T and Christie. 1993. Plant breeding: theory and Practice. Scientific Publishers(India) Jodhpur.

PBG 513**Molecular Genetics****3(3+0)****Objective**

To impart knowledge in theory of structure and function of genetic material and major macromolecules of the cell.

Theory :

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, Genetic code, DNA transcription and its regulation – Transcription factors and their role; regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors, mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; Gene amplification and its significance; Proteomics and protein-protein interaction, split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters, regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing, genomics and proteomics; Functional and pharmacogenomics; Metagenomics. Signal transduction; Genes in development; Cancer and cell aging, methods of studying polymorphism at biochemical and DNA level;

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1	Historical Background of Molecular Genetics	1
2	Genetic material and properties of nucleic acid	2
3	Genetic code	1
4	Transcription and its regulation	1
5	Transcriptional factors	1
6	Protein synthesis and its regulation in pro and eukaryotes	1
7	t RNAs and translational factors	1
8	Mechanism of recombination	1
9	DNA organization in eukaryotic chromosomes	1
10	Unique and repetitive sequences : its discovery and types	1
11	Gene amplification, mechanism of gene duplication, significance	1
12	Split genes, overlapping genes and pseudogenes	1
13	Oncogenes. Gene families and clusters	1
14	Proteomics : definition and protein -protein interactions	1
15	Transposable elements: discovery, characteristics in prokaryotes	2
16	Transposable elements : eukaryotic. Genetic consequences of transposition.	1
17	Gene regulation in prokaryotes: positive, negative and attenuation	2
18	Gene regulation in eukaryotes	2
19	Molecular mechanism of mutation: tuatomerism, types of mutation	1
20	Suppressor mutation and repair, NER/BER, SOS	2
21	Molecular chaperones and RNA editing	1
22	Genomics : definition, genome projects, structural and functional genomics	1
23	Pharmacogenomics and Metagenomics	1
24	Signal transduction : Rhizobium nodulation case study.	1
25	Genes in development, cancer and cell againg	1
26	Methods of studying polymorphism at molecular level: isozyme pattern, RFLP,RAPDs , AFLPs and SNPs.	3

Suggested Readings

- Bruce A.2004. *Essential Cell Biology*.
 Friefelder, D. 1990. *Molecular genetics*. Narosa Publishing house, New Delhi.
 Karp G.2011 .*Cell and Molecular Biology: Concepts and Experiments*. 6th Edn. John Wiley.
 Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman & Co.
 Lewin B. 2008. *IX Genes*. John Wiley & Sons
 Lodish H, Berk A & Zipursky SL. 2004. *Molecular Cell Biology*. 5th Ed.
 Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
 Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley Publ. Co.WH Freeman & Co.
 WH Freeman. Nelson DL & Cox MM. 2005. *Lehninger's Principles of Biochemistry*.
 Winter, P C., Hickey, G I., and Fletcher, H L. 1999. *Instant Notes in Genetics*. Viva Book Pvt. Ltd. New Delhi.

PBG 521

Plant genetic resources & seed technology

3(2+1)

Theory:

Genetic resources in historical perspectives, gene pool, centres of origin and diversity. Types of genetic resources and their survey- objectives, limitations, priorities and techniques. Germplasm introduction and exchange. Principles of *in vitro* and cryopreservation. Germplasm conservation *in-situ*, *ex situ* and on farm, short, medium, long term conservation strategies for orthodox and non-orthodox seed, vegetatively propagated cops. Rajasthan of plant genetic resources, PGR data base management, descriptors. Regional, national and international mechanism for PGR management. Plant genetic resources for food and agriculture. PGR access and benefit sharing; IPR, PBR, UPOV & CBD issues; farmers' rights & privilege, History of seed industry and role of various seed organizations. Seeds act and seed rules and law enforcement. Seed control order. New seed act seed policy. Variety: definition, types,

development, release system and notification. Objectives and principles of seed production. Factors affecting seed production, variety maintenance, nucleus and breeder seed production in different crop groups. Production of certified and foundation seed in different crop plants viz; cereals, oilseeds, pulses, fibre and forage crops. Concept, purpose and phases of seed certification, seed certification agency. Variety eligibility, class and sources of seed, field inspection and minimum seed and field certification standards. DUS test and VCU. Variety identification through biochemical procedures.

Practical:

Seed testing methods and seed dormancy. Seed production planning in different crops with special reference to land and isolation requirements. Roguing, harvesting and threshing. Character of important varieties and its maintenance. Field inspection at different crop growth stages off types, pollen shedders, seed borne diseases. Visit to seed production plots. Visit to gene bank.

Lecture schedule : Theory

S.No.	Topic	No. of lectures
1	Genetic resources in historical perspectives	1
2	Gene pool, centers of origin and diversity	1
3	Types of genetic resources	1
4	Genetic resources and their survey	1
5	Germplasm introduction and exchange	1
6	Principles of <i>in vitro</i> and cryopreservation	1
	Germplasm conservation: i. Types and material conserved	1
8	ii. Conservation strategies	1
9	iii. Seed Gene Bank	1
10	Registration of plant genetic resources	1
	Regional & National activities for PGR management	1
	International activities for PGR management	1
13	Plant genetic resources for food and agriculture	1
14	PGR access resources and benefit sharing	1
15	IPR, PBR, UPOV & issues, farmers right etc.	1
16	History of seed industry	1
17	Role of various seed organizations	1
18	Seeds Act and Seed Rules	1
19	Law enforcement and powers of seed inspectors	1
20	New seed act, inspection procedure	1
21	Variety development, evaluation, release and notification	1
22	Objectives and principles of seed production	1
	Factors affecting seed production and variety maintenance	1
24	Production and maintenance of nucleus and breeder seed in different crop groups (Varieties)	1
25	Production and maintenance of nucleus and breeder seed in different crop groups (Hybrids)	1
	Production of foundation and certified seed in cereals crops	1
	Production of foundation and certified seed in oilseeds crops	1
	Production of foundation and certified seed in pulses and forage crops	1
29	Seed certification- concept, purpose, phases and certification agencies.	1
30	Variety eligibility, classes and sources of seed etc.	1
31	Field inspection and minimum seed and field standards for certification	1
32	DUS test, VCU and variety identification.	1

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1	Seed testing : i. Viability	1
2	ii. Health	1
3	iii. Moisture	1

4	iv. Purity	1
5	Seed dormancy	1
6	Seed production planning in cereal crops (Nucleus, breeder, foundation, certified)	1
7	Seed production planning in pulses crops (Nucleus, breeder, foundation, certified)	1
8	Seed production planning in oil seed crops (Nucleus, breeder, foundation, certified)	1
9	Seed production planning in millet crops (Nucleus, breeder, foundation, certified)	1
10	Seed production planning in forage crops (Nucleus, breeder, foundation, certified)	1
11	Characters of important cereals and millets crop varieties and their maintenance	1
12	Characters of important oilseed, pulses and forages crop varieties and their maintenance	1
13	Field inspection at different growth stages	1
14	Pollen shedders and seed borne diseases	1
15	Visit to seed production plots	1
16	Visit to gene bank	1

Suggested Readings:

- Dhirendra Khare and Mohan S. Bhale, 2000. Seed Technology. Scientific Publishers, P.O. Box 91, Jodhpur.
- F.L. Brian and M. Jackson, 1986. Plant Genetics Resources- An introduction to their conservation and use. Edward Annold, London.
- Gautam, P.L., Dabas, B.S., Srivastava, V and Duhoon, D.S. (Eds.), 1988. Plant Germplasm Collecting Principles and Procedures. NBPGR Publication, NBPGR, New Delhi.
- J.H.W. Holden and J.T. Williams, 1984. Crop Genetic Resources, Conservation and Evaluation. Oxford Books and Stationary Co., Delhi.
- N. Ghosh and Subirsen, 1999. Seed Science and Technology. Kalyani Publishers, Ludhiana.
- Paroda, R.S., Arora, R.K. and Chandel, K.P.S. (Eds.), 1988. Plant Genetic Resources. Indian Perspective. NBPGR, New Delhi.
- R.L. Agrawal, 1996. Seed Technology. IBH Publishing CO., New Delhi.
- Tomar, H.S., 2003. Seed Technology. Aman Publishing House, Meerut (U.P.)

PBG 522

Principles of Quantitative Genetics

3(2+1)

Objective

To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory

Population -Mendelian population – Random mating population -Frequencies of genes and genotypes-Causes of change: Hardy- Weinberg equilibrium, Mendelian traits vs polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects, principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance, designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D² analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance, generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

Practical :

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis -Metroglyph analysis - D² analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and

interpretation of results -Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression -Generation mean analysis: Analytical part and Interpretation -Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model -Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems -Biplots and mapping genotypes.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1	Population : Mendelian population, Random mating population, Frequencies of genes and genotypes.	1
2	Causes of change: Hardy- Weinberg equilibrium.	1
3	Mendelian traits vs polygenic traits, nature of quantitative traits and its inheritance, Multiple factor hypothesis, analysis of continuous variation.	1
4	Concept of genotypic, phenotypic and breeding value. Population mean, additive and dominance variance etc.	1
5	Variations associated with polygenic traits - phenotypic, genotypic and environmental & non-allelic interactions.	1
6	Nature of gene action - additive, dominance, epistatic and linkage effects.	1
7	Principles of Analysis of Variance (ANOVA), Expected variance components, random and fixed models.	1
8	MANOVA, biplot analysis.	1
9	Comparison of means and variances for significance.	1
10	Designs for plant breeding experiments – principles and applications.	1
11	Commonly used designs: RBD and CRD.	1
12	LSD and Augmented Design.	1
13	Genetic diversity: Metroglyph analysis.	1
14	Cluster and D ² analyses.	1
15	Association analysis – phenotypic, genotypic covariances & correlations.	1
16	Regression analysis including parent-progeny regression.	1
17	Path analysis.	1
18	Discriminant function analysis.	1
19	Principal component analyses	1
20	Concepts of selection, Selection indices & selection of parents.	1
21	Simultaneous selection models.	1
22	Heritability and genetic advance.	1
23	Generation mean analysis.	1
24	Concepts of combining ability and gene action. Introduction to mating designs.	1
25	Diallel analysis: Hayman's approach	1
26	Diallel analysis: Griffing's approach	1
27	Partial diallel and line x tester analysis	1
28	Biparental mating (NCDs)	1
29	Triple Test Cross etc..	1
30	Analysis of genotype x environment interaction - adaptability and stability.	1
31	Models for G x E analysis and stability parameters.	1
32	AMMI analysis – principles and interpretation.	1

Lecture schedule :Practical

S.No.	Topic	No. of lectures
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1	Problems on multiple factors inheritance, Partitioning of variance, Estimation of heritability and genetic advance.	1
2	Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions	1
3	Covariance analysis. Correlation and regression analysis. Parent-progeny regression analysis	1
4	Metroglyph analysis - D ² analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation	1
5	Diallel analysis: Hayman's graphical approach, interpretation of results.	1
6	Diallel analysis: Griffing's methods I and II, interpretation of results.	1
7	North Carolina Designs and their interpretations.	1
8	Line x tester analysis and interpretation of results.	1
9	Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression	1
10	Generation mean analysis: Analytical part and Interpretation -Estimation of different types of gene actions.	1
11	Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping;	1
12	Working out efficiency of selection methods in different populations and interpretation.	1
13	Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC): use of softwares in analysis and result interpretation.	1
14	Advanced biometrical models for combining ability analysis	1
15	Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model -Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model	1
16	Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems -Biplots and mapping genotypes.	1

Suggested Readings

Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall. Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman. Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.

Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall. Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani. Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani. Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani. Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

PBG 523

Biotechnology for Crop Improvement

3(2+1)

Objective

To impart knowledge and practical skills to use biotechnological tools in crop improvement.

Theory

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding. Tissue culture-History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation. Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR-based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs). Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F₂s, back crosses, RILs, NILs and DH). Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis,

Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Marker-assisted backcross breeding for rapid introgression, Generation of EDVs. Gene pyramiding. Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases. Biotechnology applications in male sterility/hybrid breeding, molecular farming. Gene silencing. MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights . Bioinformatics & Bioinformatics tools. Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration -Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation UNIT. Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1	Biotechnology and its relevance in agriculture; definitions, terminologies and scope in plant breeding.	2
2	Tissue culture- History, callus, suspension cultures, cloning.	2
3	Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques.	1
4	Ovary and embryo culture; cryopreservation.	1
5	Genotyping; Sequencing techniques	2
6	Vectors, vector preparation and cloning	1
7	Recombinant DNA technology, transgenes, method of transformation	2
8	Selectable markers and clean transformation techniques,	1
9	vector-mediated gene transfer, physical methods of gene transfer	1
10	Production of transgenic plants in various field crops: cotton, wheat, maize	2
11	Rice, soybean, oilseeds, sugarcane etc. Commercial releases	2
12	Biotechnology applications in male sterility/hybrid breeding, molecular farming.	1
13	Biochemical and molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.)	2
14	Mapping populations (F ₂ s, back crosses, RILs, NILs and DH).	1
15	Molecular mapping and tagging of agronomically important traits	2
16	Statistical tools in marker analysis, Robotics, QTLs analysis in crop plants	2
17	Marker-assisted selection for qualitative and quantitative traits, Gene pyramiding.	1
18	Marker assisted selection and molecular breeding	1
19	Genomics for crop improvement	1
20	Integrating functional genomics information on agronomically/economically important traits in plant breeding;	2
21	Marker-assisted backcross breeding for rapid introgression, Generation of EDVs	2
22	MOs and related issues (risk and regulations);	1
23	GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in India, ethical, legal and social issues;	2
24	Intellectual property rights	1
25	Introduction to Bioinformatics & Bioinformatics tools	1
26	Introduction to Nanotechnology and its applications in crop improvement programmes.	1

Lecture schedule :Practical

S. No.	Topic	No. of lectures
1	Requirements of a tissue culture laboratory, tissue culture techniques, media preparation	1

2	Sterilization techniques	1
3	Inoculation techniques	1
4	Callus induction and plant regeneration	1
5	Regeneration protocols	1
6	Green house and hardening procedures	1
7	Visit to commercial micropropagation units	1
8	Transformation using Agrobacterium strains	1
9	Gus assay in transformed cells/tissues	1
10	DNA isolation	1
11	DNA agarose gel electrophoresis , DNA purity and quantization	1
12	Gel Electrophoresis of proteins and isozymes	1
13	DNA amplification using PCR	1
14	Assessing RAPD marker	1
15	Gel scoring and data analysis and tagging phylogenetic relationship	1
16	Construction of genetic linkage map using computer software	1

Suggested Readings

Chawala H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.

Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA & Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

Sambrook J & Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani.

PBG 524

Principles of Cytogenetics

3(2+1)

Objective

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory :

Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome structure: Evolutionary significance -Introduction to techniques for karyotyping; Chromosome banding and painting -in situ hybridization and various applications. Structural and Numerical variations of chromosomes and their implications - Symbols and terminologies for chromosome numbers - euploidy -haploids, diploids and polyploids ; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction ; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes. Inter-variatal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids – Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization; Apomixis - Evolutionary and genetic problems in crops with apomixes.

Reversion of autopolyploids to diploids; Genome mapping in polyploids - Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids - Bridge species.

Fertilization barriers in crop plants at pre-and postfertilization levels- In vitro techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization ; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical :

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, Preparing specimen for observation -Fixative preparation and fixing specimen for light microscopy studies in cereals -Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion. Studies on the course of meiosis - Using micrometers and studying the pollen grain size in various crops - Pollen germination and in vitro; Demonstration of polyploidy.

Lecture schedule : Theory

S. No.	Topic	No. of lectures
1	Architecture of chromosome in prokaryotes: Nucleoid etc.	1
2	Architecture of chromosome in eukaryotes: Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere	1
3	Artificial chromosome construction and its uses	1
4	Special types of chromosomes.	1
5	Introduction to techniques for karyotyping;	1
6	Chromosome banding and painting	1
7	In situ hybridization and various applications.	1
8	Variation in chromosome structure: Evolutionary significance	1
9	Numerical variations of chromosomes and their implications - Symbols and terminologies for chromosome numbers	1
10	Euploidy –haploids, diploids and polyploids	1
11	Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids	1
12	Utilization of aneuploids in gene location	1
13	Variation in chromosome behaviour - somatic segregation and chimeras	1
14	Endomitosis and somatic reduction	1
15	Evolutionary significance of chromosomal aberrations	1
16	Balanced lethals and chromosome complexes	1
17	Balanced lethals and chromosome complexes	1
18	Inter-varietal chromosome substitutions	1
19	Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer	1
20	Alien addition and substitution lines – creation and utilization	1
21	Apomixis - Evolutionary and genetic problems in crops with apomixes.	1
22	Reversion of autopolyploids to diploids	1
23	Genome mapping in polyploids	1
24	Interspecific hybridization and allopolyploids	1
25	Synthesis of new crops (wheat, triticale and brassica)	1
26	Hybrids between species with same chromosome number	1
27	Hybrids between species with different chromosome number, alien translocations	1
28	Gene transfer using amphidiploids - Bridge species.	1
29	Fertilization barriers in crop plants at pre-and postfertilization levels	1
30	In vitro techniques to overcome the fertilization barriers in crops	1
31	Chromosome manipulations in wide hybridization	1
32	Case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.	1

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1	Learning the cytogenetics laboratory	1
2	Various equipments used in cytogenetics laboratory	1
3	Various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc.	1
4	Microscopy: Introduction and parts.	1
5	Various types of microscopes	1
6	Preparing specimen for observation	1

7	Fixative preparation and fixing specimen for light microscopy studies in cereals	1
8	Studies on the course of mitosis in wheat	1
9	Studies on the course of mitosis in pearl millet	1
10	Studies on the course of mitosis in onion	1
11	Studies on the course of meiosis	1
12	Studies on the course of meiosis	1
13	Using micrometers and studying the pollen grain size in various crops 1	1
14	Using micrometers and studying the pollen grain size in various crops 2	1
15	Pollen germination	1
16	Demonstration of polyploidy.	1

Suggested Readings

- B.D.Singh. 2005. Genetics. Kalyani Publishers
 Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.
 Carroll M. 1989. Organelles. The Guilford Press.
 Charles B. 1993. Discussions in Cytogenetics. Prentice Hall.
 Darlington CD & La Cour LF. 1969. The Handling of Chromosomes.
 Gray P. 1954. The Microtome's Formulary Guide. The Blakiston Co.
 Gupta PK & Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A. Elsevier.
 Gupta PK. 2000. Cytogenetics. Rastogi Publ.
 Johansson DA. 1975. Plant Microtechnique. McGraw Hill.
 Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons
 Khush GS. 1973. Cytogenetics of Aneuploids. Academic Press.
 Sharma AK & Sharma A. 1988. Chromosome Techniques: Theory and Practice.
 Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ.
 Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

PBG 531

Mutagenesis and Mutation Breeding

3(2+1)

Objective

To impart the knowledge about general principles of radiation and various tests/methods for detection of radiation effects on the living cells, genetic risks involved and perspectives of advances made.

Theory

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms - paramutations. Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations *viz.*, X rays, γ rays, α and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects - RBE and LET relationships. Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute *vs* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume. Chemical mutagens- Classification - Base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action - Dose determination and factors influencing chemical mutagenesis Treatment methods using physical and chemical mutagens - Combination treatments; Other causes of mutation - direct and indirect action, comparative evaluation of physical and chemical mutagens. Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras *etc.*, - Observing mutagen effects in M2 generation - Estimation of mutagenic efficiency and effectiveness - spectrum of chlorophyll and viable mutations - Mutations in traits with continuous variation. Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc.* - Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same

species – Case studies. Use of mutagens in creating oligogenic and polygenic variations – Case studies -*In vitro* mutagenesis – callus and pollen irradiation; Handling of segregating generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc) in different crops- Procedures for micro-mutations breeding/polygenic mutations- Achievements of mutation breeding-varieties released across the world- Problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical

Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity – Production of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring – safety regulations and safe transportation of radioisotopes -Visit to radio isotope laboratory ; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens - Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; Raising the crop for observation - Mutagenic effectiveness and efficiency; Calculating the same from earlier literature - Study of M1 generation – Parameters to be observed; Study of M2 generation – Parameters to be observed; Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Lecture schedule : Theory

SN	Topic	No.of lectures
1	Historical perspectives and definition of mutation	1
2	Different ways of classification of mutations	2
3	Mutation detections systems, paramutation	1
4	Mutagenic agents : Physical; different particulate & aparamiculate radiations	1
5	Mode of action of gamma rays, photoelectric effect, Compton scattering and ion pair production and their effects on biological system	1
6	Repair mechanisms, mutation rate, frequency, dosimetry	2
7	Internal and external factors affecting influencing mutations	1
8	Chemical mutagens, classification, types and mode of actions	2
9	Combination treatments and comparisons	1
10	Treatment procedures and factors to be considered	2
11	Mutagen specificity	2
12	Observing mutagen effects, criteria of biological damage , quantification of damage using germination, chromosomal aberration and gametic sterility, and estimating spectrum of mutation	2
13	estimation of mutagenic effectiveness and efficiency using biological damage and spectrum of mutations observed in M1 & M2 populations	2
14	Factors influencing mutation spectrum: genotype, pleiotropy, linkage, type of mutagen. Case studies	2
15	Use of mutagens for creating oligo and polygenic mutations, rationale for using mutation breeding, selection sieves, size of mutated populations to be handled,	2
16	Handling of M1 , M2 and subsequent generations for identification of mutants..	2
17	Mutations breeding for various traits	1
18	Achievements of mutation breeding	2
19	Use of mutations in genomics, allele mining	2
20	TILLING	1

Lecture schedule : Practical

S.No.	Topic	No. of
1	Learning precautions on handling of mutagenic agents	1
2	Physical mutagens: dosimetry	2
3	Radioactivity: production of source and isotopes at BRIT, Trombay	1
4	Learning about gamma chamber, radiation hazards, monitoring, safety regulations, and safe transportation of radioisotopes.	2
5	Visit to radioisotope laboratory	1
6	Treating plant propagules (seeds) with graded dose of different chemical mutagens, Computing LD50 for different crops of interest	4
7	Estimating biological damage	2

8	Learning combined mutagenic effect, raising the crop for estimating the mutagenic efficiency and effectiveness using data from the literature.	2
9	Studying M1 and M2 parameters	1

Suggested Readings

- Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.
- Chadwick KH & Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer-Verlag.
- Cotton RGH, Edkin E & Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energy Agency, Vienna, Italy.
- Singh BD. 2007. *Genetics*. Kalyani.
- Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

PBG 532

Heterosis Breeding

3(2+1)

Objective

To provide understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Theory

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects -Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops. Pre Mendelian and Post-Mendelian ideas -Genetic theories of heterosis –Physiological, Biochemical and molecular actors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis. Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. - Relationship between genetic distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis. Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids. Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid. Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis. Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Selection indices and selection differential – Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops -Estimation from the various models for heterosis parameters -Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Lecture schedule : Theory

S.No.	Topic	No. of lectures
1	Genetic structure of population in relation to mode of pollination	1
2	Historical aspect of heterosis - Nomenclature and definitions of heterosis	1

3	Heterosis in natural population and inbred population	1
4	Inbreeding-Introduction and effect of inbreeding, coefficient of inbreeding, Inbreeding depression	1
5	Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops	1
6	Pre Mendelian and Post-Mendelian ideas about heterosis.	1
7	Genetic theories of heterosis- Genetic basis of heterosis-dominance and overdominance hypothesis	1
9	Physiological and Biochemical basis of heterosis	1
9	Molecular factors underlining heterosis	1
10	Prediction of heterosis from various crosses	1
11	Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations,	1
12	Importance of inbreeding in exploitation of heterosis	1
13	Relationship between genetic distance and expression of heterosis	1
14	Divergence and Genetic Distance analyses	1
15	Morphological and molecular genetic distance in predicting heterosis	1
16	Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.	1
17	Types of male sterility and use in heterosis breeding	1
18	Maintenance, transfer and restoration of different types of male sterility	1
	Self-incompatibility and uses of SI in development of hybrids	1
19	Hybrid seed production system using 3-line, 2-line and 1-line system	1
20	Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.	1
21	Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops;	1
22	Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops	1
23	Problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid	1
24	Application of biotechnology in heterosis breeding- molecular markers, doubled haploids, somatic hybridization.	1
25	Organelar heterosis and complementation	1
26	Creation of male sterility through genetic engineering and its exploitation in heterosis	1
27	Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops	1
28	Heterosis breeding in Rice	1
29	Heterosis breeding in Maize	1
30	Heterosis breeding in pearl millet	1
31	Heterosis breeding in sorghum	1
32	Heterosis breeding in oilseed crops	1

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1	Selection indices and selection differential – Calculations and interpretations	1
2	Male sterile line characterization in millets; Using morphological descriptors	1
3	Restorer line identification and diversification of male sterile sources	1
4	Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them	1
5	Male sterile line creation, diversification and restoration in forage crops	1
6	Understanding the difficulties in breeding apomicts;	1
7	Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters	1
8	Practical aspects of hybrid seed production using different crossing techniques	1

9	Hybrid seed production in cereals	1
10	Hybrid seed production in pulses	1
11	Hybrid seed production in oilseed crops	1
12	Hybrid seed production in fibre crops	1
13	Hybrid breeding at National and International level	1
14	Identification of maintainers and restorers (maize, sorghum, bajra, wheat, rice and brassica	1
15	Identification and characterization of important hybrids in field crops	1
16	Field visit of hybrid seed production plots	1

Suggested Readings

Proceedings of *Genetics and Exploitation of Heterosis in Crops* - An International Symposium CIMMYT, 1998.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben Hiu Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

De Joung G. 1988. *Population Genetics and Evolution*. Springer-Verlag.

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE & Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall.

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed. Wiley & Sons.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Srivastava S & Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.

Rai, B. Heterosis breeding. Agro-biological publications, New Delhi.

PBG 612

Advanced Genetics

3(3+0)

Theory:

Secondary structures of DNA (A,B,C,Z and P- DNA). Denaturation and renaturation of DNA- supercoils, cruciforms and triple stranded structures. Secondary and tertiary structures of RNA. Ribozyme and deoxyribozymes. Physico chemical organization of chromatin and nucleosome, concept. Telomerases . DNA repair and recombination. Gene duplication, amplification and pseudogenes; Arrangements of genes in eucaryotes. Mobile genetic elements in pro and eucaryotes and their significance. Organization of mitochondrial and chloroplast genomes, Plasmid biology. Aims and principles of gene transfer, vectors, restriction enzymes, distinguishing transferred genes from endogenous genes.. *In vitro* synthesis of recombinant DNA and gene cloning techniques, developmnt of transgenic plants and potential hazards of gene cloning. Molecular Markers, types and significance. Genome projects, genomics, proteomics

Lecture schedules : Theory

S. No.	Topic	No. of lectures
1	Secondary structures of DNA (A, B, C, Z and P- DNA)	2
2	Denaturation and renaturation of DNA- Introduction	1
3	Supercoils, cruciforms and triple stranded structures	1
4	Secondary and tertiary structures of RNA	1
5	Ribozyme and deoxyribozymes	2
6	Physico chemical organization of chromatin	2
7	Nucleosome, higher order organization of chromatid	2
8	Telomerases	1
9	DNA repair (including SOS)	3
10	Recombination (molecular basis and models)	1
11	Gene duplication, amplification and pseudogenes	1
12	Gene duplication: evolutionary significance	1

13	Arrangements of genes in eucaryotes	2
14	Mobile genetic elements in procaryotes	2
15	Significance of mobile genetic elements in procaryotes	1
16	Mobile genetic elements in eucaryotes	1
17	Significance of mobile genetic elements in eucaryotes	1
18	Organization of mitochondrial genomes	2
19	Organization of chloroplast genomes	2
20	Introduction to gene transfer and its aim	1
21	Principles of gene transfer	1
22	Introduction to vectors, their types and role in gene transfer	1
23	Introduction to restriction enzymes, their types and role in gene transfer	1
24	Distinguishing transferred genes from endogenous genes	2
25	<i>In vitro</i> synthesis of recombinant DNA and gene cloning techniques	2
26	Application and potential hazards of gene cloning.	1
27	Molecular markers : Introduction	1
28	Molecular markers: types - RFLP	1
29	Molecular markers: types - RAPD	1
30	Molecular markers: types – AFLP and others	1
31	Molecular markers: significance	1
32	Human genome project	1
33	Genome projects of other major crops	2
34	Genomics	1
35	Proteomics	1

References:

- Lewin, B. 2000 Genes VII. Oxford Univ. Press, New York.
Brown, T.A. 1998. Genomes. John Wiley and Sons (East Asia). Singapore.
Alberts, B. et al 1994. Molecular Biology of the cell 3rd. Garland Publishing, New York.
Singh B.D. 1990. Fundamental of genetics. Kalyani Publishers, Ludhiyana.
Karp, G. 1999. Cell and Molecular Biology. John Wiley and Sons (East Asia). Singapore.
Freifelder, D. 1995. Molecular Biology. Narosa Publishing House, New Delhi.
Birge EA 1988. Bacterial and Bacteriophage Genetics, 2nd Edition. Springer Verlag.

PBG 614

Advanced Biometrical and Quantitative Genetics

3(2+1)

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes. Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis. Additive and multiplicative model -Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model -Biplots and mapping genotypes. Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance - Construction of saturated linkage maps, concept of framework map development; QTL mapping-Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on

markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of softwares in analysis and result interpretation - Trialallel analysis– use of softwares in analysis and result interpretation - Quadriallel analysis – use of softwares in analysis and result interpretation - Triple Test Cross (TTC) – use of softwares in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model -Shifted multiplicative model -Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes. Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Lecture schedules : Theory

S. No.	Topic	No. of lectures
1	Basic principles of Biometrical Genetics.	1
2	Selection of parents.	1
3	Advanced biometrical models for combining ability analysis.	1
4	Simultaneous selection models.	1
5	Use of Multiple regression analysis in selection of genotypes	1
6	Designs and Systems.	1
7	Concepts of combining ability and gene action. Introduction to mating designs.	1
8	Diallel analysis: Hayman’s approach	1
9	Diallel analysis: Griffing’s approach	1
10	Partial diallel and line x tester analysis	1
11	Biparental mating (NCDs)	1
12	Triple Test Cross etc..	1
13	Genotype x environment interaction	1
14	Selection of stable genotypes.	1
15	Models in stability analysis.	1
16	Additive Main Effect and Multiplicative Interaction (AMMI) analysis	1
17	Other related models in stability analysis.	1
18	Principal Component Analysis.	1
19	Additive and multiplicative model.	1
20	Shifted multiplicative model.	1
21	Analysis and selection of genotypes.	1
22	Methods and steps to select the best model.	1
23	Biplots and mapping genotypes	1
24	Genetic architecture of quantitative traits.	1
25	Conventional analyses to detect gene actions.	1
26	Partitioning of phenotypic/genotypic variance.	1
27	Construction of saturated linkage maps & concept of framework map development.	1
28	QTL mapping-Strategies for QTL mapping - desired populations, statistical methods.	1
29	Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding.	1
30	Selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS	1
31	Heritability of the trait, proportion of genetic variance.	1
32	Linkage disequilibrium between markers and traits and selection methods	1

Lecture schedule : Practical

S. No.	Topic	No. of lectures
1	Working out efficiency of selection methods in different populations and interpretation.	
2	Biparental mating – use of softwares in analysis and result interpretation.	

3	Triallel analysis – use of softwares in analysis and result interpretation.	
4	Quadriallel analysis – use of softwares in analysis and result interpretation.	
5	Triple Test Cross – use of softwares in analysis and result interpretation.	
6	Advanced biometrical models for combining ability analysis.	
7	Selection of stable genotypes using stability analysis.	
8	Additive Main Effect and Multiplicative Interaction (AMMI) model.	
9	Principal Component Analysis model.	
10	Additive and multiplicative model.	
11	Shifted multiplicative model.	
12	Methods and steps to select the best model.	
13	Biplots and mapping genotypes.	
14	Construction of linkage maps and QTL mapping.	
15	Strategies for QTL mapping; statistical methods in QTL mapping.	
16	Phenotype and Marker linkage studies.	

Suggested Readings

Bos I & P Caligari. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
 Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*.
 Longman. Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall. Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
 Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
 Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
 Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

PBG 621

Genetic Engineering

3(2+1)

Theory:

Perspectives and application of genetic engineering. Methods of recombinant technology. Isolation, sequencing, cloning of prokaryotic and eucaryotic genes. Basic differences in the expression of pro and eukaryotic gene expression. Analytical techniques in in genetic engineering. Immunogenetics. Nature and function of restriction enzymes. Plasmid structure, function and biology. Construction of plasmid vectors. Biology of bacteriophage lambda and M13. Specialised vectors. Gene cloning in plasmids . *Agrobacterium* plasmids (Ti and Ri). Methods of direct gene transfer-elctroporation, microinjection, use of particle gun. Construction of genomic libraries. PCR and its use Genetic manipulation, construction of transgenic in pro and eucaryotes.

Practicals

Isolation of DNA. DNA melting, annealing and plotting of cot values, isolation of plasmid DNA, Protoplast fusion, Triparental mating. Visit to the Biotechnology laboratories of national repute.

Lecture schedule : Theory

.SNo.	Topic	No. of lectures
1	Perspectives and application of genetic engineering	1
2	Methods of recombinant technology	2
3	Sanger's method of DNA sequencing, other sequencing technologies	1
4	Strategies for isolation of prokaryotic and eukaryotic genes	2
5	Basic differences in the expression of pro and eukaryotic gene expression	1
6	Analytical techniques in in genetic engineering	2
7	Immunogenetics : antibody structure, gene controlling antibody formation, antibody diversity, applications	2
8	Nature and function of restriction enzymes: Host restriction modification, type II restriction enzymes	1
9	Plasmid structure, function and biology: plasmid evolution, types, significance	3
10	Construction of plasmid vectors	2

11	Biology of bacteriophage lambda and M13	2
12	Specialised vectors : YAC, BAC, PAC	2
13	Gene cloning in plasmids	1
14	<i>Agrobacterium</i> plasmids (Ti and Ri)	2
15	Methods of direct gene transfer-electroporation, microinjection, use of particle gun	2
16	Construction of genomic libraries: Genomic and cDNA library, strategy, use of phage vector for library	2
17	PCR and its use Genetic manipulation	2
18	construction of transgenic in pro and eukaryotes..	2

Lecture schedule : Practical

S.No.	Topic	No. of lectures
1	Isolation of DNA	2
2	DNA melting, annealing and plotting of cot values	3
3	Isolation of plasmid DNA : Culturing bacteria harboring plasmid, isolation of DNA, gel electrophoresis and Ethidium bromide staining to visualize the plasmid and quantifying its molecular weight.	4
4	Protoplast fusion	2
5	Tri-parental mating	3
6	Visit to the biotechnology laboratory at Jaipur and Bikaner/IARI	2

Suggested Readings

Old, R.W. and Primrose, S.B. 2001. Principles of Genetic manipulation: An Introduction to Genetic Engineering, 5th Edition. Blackwell Scientific Limited, USA.

Singh, B.D. 1999. Biotechnology. Kalyani Publishers, Ludhiana.

Liu Ben Hui. 1998. Statistical Genomics : Linkages, Mapping and QTL Analysis. CRC Press LLC, Florida, USA.

Chawala, H.S. 2002. Introduction to plant biotechnology, 2nd edition. Oxford& IBH, New Delhi

Freifelder, D. 2000. Microbial Genetics. Narosa Publishing House, New Delhi.

Birge EA 1988. Bacterial and Bacteriophage Genetics, 2nd Edition. Springer Verlag.

PBG 624

Breeding Designer Crops

3(2+1)

Objective

To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification and industrial/pharma applications in plant breeding.

Theory

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats. Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement. Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations. Breeding for special traits viz. oil, protein, vitamins, amino acids etc.; Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories

in vaccines, modified sugars, gums and starch through biopharming. Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

Practical

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

Lecture schedule : Theory

S.No.	Topic	No. of lectures
1	Concept of ideotype breeding	2
2	Genetic manipulation through recombination breeding,genomics and transgenics for designer crops for physiological efficiency, nutritional enhancement, special compound proteins, vaccines, gums, starch & fats : case studies.	4
3	Physiological efficiency as a concept : parametric and holistic	3
4	Improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green traits for crop improvement	4
5	Manipulation of source sink , canopy architecture, plant water relationship	3
6	Effect of cardinal plant growth and development process	2
7	Genetic manipulation for input use efficiency	3
8	Breeding for special traits	3
9	Biopharming for industrial development	3
10	Success stories in vaccines, modified sugars, gums and starch	3
11	Biosafety management, segregation and isolation requirement and post harvest management	2

Lecture Schedule : Practical

SN	Topic	No. of lectures
1	Growing plants under stressed and non-stressed conditions for demonstration of plant responses to stresses through recent techniques	2
2	Water use efficiency, transpiration efficiency : learning equations and method of determination.	2
3	screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation	7
4	heat/drought/salt shock proteins using crop genotypes known for stress tolerance : demonstration of protein using Protein electrophoresis using sensitive & resistant genotype of the crop.	5

Suggested Readings :

Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK

Ademiaikiado. Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed.

Blackwell. Pessaraki M. 1995. *Handbook of Plant and Crop Physiology*. Marcel

Dekker. Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PLANT PATHOLOGY

S.No.	Course No	Title	Credit Hrs.
M. Sc. (Ag)			
I-Semester			
1.	PPATH-511	Mycology	3(2+1)
2.	PPATH-512	Detection and Diagnosis of Plant Diseases	3(0+3)
3.	PPATH-513	Principles of Plant Pathology	3(3+0)
II-Semester			
4.	PPATH-522	Plant Bacteriology	3(2+1)
5.	PPATH-523	Diseases of Vegetables and Spices Crops	3(2+1)
6.	PPATH-526	Ecology of Soil-borne Plant Pathogens	3(2+1)
III-Semester			
7.	PPATH-531	Plant Virology	3(2+1)
8.	PPATH-532	Principles of Plant Disease Management	3(2+1)
9.	PPATH-533	Diseases of Field and Medicinal Plants	3(2+1)
IV-Semester			
10.	PPATH-541	Seminar	1
11.	PPATH-542	Comprehensive	2
12.	PPATH-543	Research	15
Ph D			
I-Semester			
13.	PPATH-611	Advanced Virology	3(2+1)
14.	PPATH-612	Molecular basis of host- pathogens interaction	3(2+1)
II-Semester			
15.	PPATH-621	Advanced Mycology	3(2+1)
16.	PPATH-622	Advanced Bacteriology	3(2+1)
III and onward Semesters			
17.	PPATH-622	Seminar	2

18.	PPATH-622	Preliminary	4
19.	PPATH-622	Research	40

Ph.D.

PPATH 611	Advanced Virology	2+1
PPATH 612*	Molecular Basis of Host-Pathogen Interaction	2+1
PPATH 621*	Advanced Mycology	2+1
PPATH 622	Advanced Bacteriology	2+1
PPATH 623	Plant Biosecurity, Biosafety & Principles of Certification	3+0
PPATH 641	Doctoral Seminar	0+2
PPATH 642	Preliminary	0+4
PPATH 643	Doctoral Research	40

* Compulsory/core courses

** Compulsory for M.Sc. Biotechnology.

M.Sc. (Ag.) Programme

PPATH 511

Mycology

3(2+1)

Objective

To study the nomenclature, classification and characters of fungi.

Theory

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs, history of mycology. Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi. The comparative morphology, ultrastructure, characters of different groups of fungi up to generic level: (a) Myxomycota and (b) Eumycota- i) Mastigomycotina ii) Zygomycotina, iii) Ascomycotina, iv) Basidiomycotina, v) Deuteromycotina. Lichens types and importance, fungal genetics and variability in fungi.

Practical

Detailed comparative study of different groups of fungi; collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi.

Lectures schedule: Theory

S. No.	Topic	No. of lectures
1.	General Introduction.	1
2.	Basic concept and definition of different terms.	3
3.	Importance of mycology in agriculture, relation of fungi to human affairs.	1
4.	History of mycology.	1
5.	Concepts of nomenclature and classification, fungal biodiversity.	3
6.	Reproduction in fungi.	2
7.	Comparative morphology, ultra structure, characters of different groups of fungi up to generic level: (a) Myxomycota and (b) Eumycota-	-
	i) Mastigomycotina	4
	ii) Zygomycotina	2
	iii) Ascomycotina	4
	iv) Basidiomycotina	4

	v) Deuteromycotina.	3
8.	Lichens types and importance.	1
9.	Fungal genetics and variability.	2

Lectures schedule: Practical

S. No.	Topic	No. of lecture(s)
1.	Comparative study of genera of orders Plasmodiophorales and Chytridiales: <i>Plasmodiophora</i> and <i>Synchytrium</i> .	1
2.	Comparative study of fungi of order Peronosporales : <i>Pythium</i> , <i>Phytophthora</i> , <i>Sclerospora</i> , <i>Peronospora</i> , <i>Plasmopara</i> and <i>Albugo</i> .	2
3.	Comparative study of genera of order Mucorales : <i>Rhizopus</i> and <i>Mucor</i>	1
4.	Comparative study of genera of order Taphrinales : <i>Taphrina</i> .	1
5.	Comparative study of genera of order Erysiphales : <i>Erysiphe</i> , <i>Uncinula</i> , <i>Microsphaera</i> , <i>Sphaerotheca</i> , and <i>Podosphaera</i>	2
6.	Comparative study of fungi of order Sphaeriales : <i>Glomerella</i> and <i>Claviceps</i> .	1
7.	Comparative study of genera of order Uredinales: <i>Puccinia</i> , <i>Uromyces</i> , <i>Phragmidium</i> and <i>Melampsora</i> .	2
8.	Comparative study of genera of order Ustilaginales : <i>Ustilago</i> , <i>Sphacelothica</i> , <i>Tolyposporium</i> , <i>Neovossia</i> , and <i>Urocystis</i> .	2
9.	Comparative study of genera <i>Colletotrichum</i> , <i>Phomopsis</i> , <i>Alternaria</i> , <i>Helminthosporium</i> , <i>Cercospora</i> , <i>Fusarium</i> etc.	2
10.	Collection, identification and preservation of specimens.	1
10.	Isolation and identification of plant pathogenic fungi.	1

Suggested Readings

Ainsworth GC, Sparrow FK & Susman HS. 1973. The Fungi – An Advanced Treatise. Vol. IV (A & B). Academic Press, New York.

Alexopoulos CJ, Mims CW & Blackwell M. 2000. Introductory Mycology. 5th Ed. John Wiley & Sons, New York.

Mehrotra RS & 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.

PPATH 512

Detection and Diagnosis of Plant Diseases

3(0+3)

Objective

To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Practical

Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens. Preservation of plant pathogens and disease specimens, use of centrifuge, pH meter, micrometer, haemocytometer, camera lucida. Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of manuscripts.

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1	Methods to prove Koch's postulates with biotroph and necrotroph pathogens	4
2	Pure culture techniques	4
3	Use of selective media to isolate pathogens	2
4	Preservation of plant pathogens and disease specimens	2
5	Use of centrifuge & pH meter	2

6	Use of micrometer haemocytometer & camera lucida	2
7	Microscopic techniques & Staining methods	4
8	Phase contrast system & Chromatography	6
9	Use of Electron microscope	2
10	Use of spectrophotometer & ultracentrifuge	2
11	Use of electrophoretic apparatus	2
12	Disease diagnostics	2
13	Serological and molecular techniques for detection of plant pathogens	6
14	Evaluation of fungicides, bactericides etc.	4
15	Field experiments and data collection	2
16	Preparation of manuscripts	2

Suggested Readings

- Baudoin ABAM, Hooper G R, Mathre D E & Carroll R B. 1990. Laboratory Exercises in Plant Pathology: An Instructional Kit. Scientific Publ., Jodhpur.
- Dhingra O D & Sinclair J B. 1986. Basic Plant Pathology Methods. CRC Press, London, Tokyo.
- Fox R T V. 1993. Principles of Diagnostic Techniques in Plant Pathology. CABI Wallington.
- Mathews R E F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Boca Raton, Tokyo.
- Pathak V N. 1984. Laboratory Manual of Plant Pathology. Oxford & IBH, New Delhi.
- Forster D & Taylor SC. 1998. Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology. Humana Press, Totowa, New Jersey.
- Matthews R E F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Florida.
- Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments. Cent. Agric. Pub. Doc. Wageningen.
- Trigiano R N, Windham M T & Windham A S. 2004. Plant Pathology- Concepts and Laboratory Exercises. CRC Press, Florida.
- Chakravarti B P. 2005. Methods of Bacterial Plant Pathology. Agrotech, Udaipur.

PPATH 513

Principles of Plant Pathology

3(3+0)

Objective

To introduce the subject of Plant Pathology, its concepts and principles.

Theory

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development. Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens. Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance. Disease management strategies.

Lectures schedule: Theory

S. No.	Topic	No. of lectures
1.	Introduction	1
2.	Importance, definitions and concepts of plant diseases.	3
3.	History and growth of Plant Pathology	3
4.	Biotic and abiotic causes of plant diseases	2
5.	Growth and reproduction of plant pathogens.	3
6.	Survival and dispersal of important plant pathogens.	1
7.	Role of environment and host nutrition on disease development.	2
8.	Host parasite interaction, recognition concept and infection.	3
9.	Symptomatology	2
10.	Disease development- role of enzymes, toxin and growth regulators	4
11.	Defense strategies- oxidative burst, phenolics, phytoalexins, PR proteins and elicitors.	4
12.	Altered plant metabolism as affected by plant pathogens.	2

13.	Genetics of resistance; R genes	2
14.	Mechanism of genetic variation in pathogens.	3
15.	Molecular basis for resistance; marker –assisted selection.	3
16.	Genetic engineering for disease resistance.	3
17.	Disease management strategies.	7

Suggested Readings

- Agrios GN. 2005. Plant Pathology. 5th Ed. Academic Press, New York.
 Heitefuss R & Williams PH. 1976. Physiological Plant Pathology. Springer Verlag, Berlin, New York.
 Mehrotra RS & Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New Delhi.
 Singh RS. 2002. Introduction to Principles of Plant Pathology. Oxford & IBH, New Delhi.
 Singh DP & Singh A. 2007. Disease and Insect Resistance in Plants Oxford & IBH, New Delhi.
 Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.

PPATH 522

Plant Bacteriology

3(2+1)

Objective

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria. Evolution, classification and nomenclature of phytopathogenic procarya and list of important diseases caused by them.

Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya. General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios. Prokaryotic inhibitors and their mode of action against phytopathogenic bacteria. Survival and dissemination of phytopathogenic bacteria.

Practical

Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics.

Lectures schedule: Theory

S. No.	Topic	No. of lectures
1	Introduction to phytopathogenic procarya viz. MLO/phytoplasma, spiroplasma	2
2	History of phytopathogenic procarya	1
3	Introduction to other fastidious procarya	2
4	Importance of phytopathogenic bacteria,	2
5	Evaluation of bacteria	1
6	Classification and nomenclature of phytopathogenic procarya	4
7	List of important diseases caused by phytopathogenic procarya	2
8	Growth and nutrition requirements of bacteria	3
9	Reproduction in prokaryotes	2
10	Preservation of bacterial cultures	1
11	Variability among phytopathogenic procarya	2
12	General biology of bacteriophage,	2
13	L-form bacteria and <i>Bdellovibrio</i>	1
14	Plasmids	2
15	Prokaryotic inhibitors and their mode of action against phytopathogenic bacteria	3
16	Survival and dissemination of phytopathogenic bacteria	2

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1	Isolation of bacteria	2
2	Purification and identification of bacteria	2

3	Inoculation and Pathogenicity of bacteria	2
4	Staining methods	2
5	Biochemical and serological characterization of bacteria	4
6	Isolation of plasmid	2
7	Use of antibacterial chemicals/antibiotics	2

Suggested Readings

- Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.
- Jayaraman J & Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publ., Ludhiana.
- Mount MS & Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.
- Verma JP, Varma A & Kumar D. (Eds). 1995. *Detection of Plant pathogens and their Management*. Angkor Publ., New Delhi.
- Verma JP. 1998. *The Bacteria*. Malhotra Publ. House, New Delhi.

PPATH -523

Diseases of Vegetables and Spices Crops

3(2+1)

Objective

To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices caused by fungal, bacterial and viral diseases and their management.

Theory

Nature, prevalence, factors affecting disease development of bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables. Diseases of protected cultivation. Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops. Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger.

Practical

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Lectures schedule: Theory

S. No.	Topic	No. of lecturers
1.	General introduction	1
2.	Diseases of potato	4
3.	Diseases of onion	1
4.	Diseases of tomato	3
5.	Diseases of garlic	1
6.	Diseases of crucifers	2
7.	Diseases of cucurbits	2
8.	Diseases of chilli	2
9.	Diseases of brinjal	2
10.	Diseases of leafy vegetables.	2
11.	Diseases of root crops	1
12.	Diseases of ginger	1
13.	Diseases of turmeric	1
14.	Diseases of saffron	2
15.	Diseases of black pepper	1
16.	Diseases of cumin	1
17.	Diseases of fenugreek	2
18.	Diseases of fennel	2
19.	Diseases of coriander	1

Lectures schedule: Practical

1.	Study of symptoms and host parasite relationship of diseases of potato	2
2.	Study of symptoms and host parasite relationship of diseases of tomato	1
3.	Study of symptoms and host parasite relationship of diseases of crucifers	1

4.	Study of symptoms and host parasite relationship of diseases of cucurbits	1
5.	Study of symptoms and host parasite relationship of diseases of chilli	1
6.	Study of symptoms and host parasite relationship of diseases of brinjal	1
7.	Study of symptoms and host parasite relationship of diseases of onion	1
8.	Study of symptoms and host parasite relationship of diseases of ginger& turmeric	1
9.	Study of symptoms and host parasite relationship of diseases of cumin	1
10.	Study of symptoms and host parasite relationship of diseases of coriander	1
11.	Study of symptoms and host parasite relationship of diseases of fenugreek	1
12.	Study of symptoms and host parasite relationship of diseases of fennel	2
13.	Collection and dry preservation of diseased specimens of important crops.	2

Suggested Readings

- Chaube HS, Singh US, Mukhopadhyay AN & Kumar J. 1992. *Plant Diseases of International Importance*. Vol.II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.
- Godara,S,I,Kapoor,BBS and Rathore,B.S.2010. Madhu Publications,Bikaner-3,India.
- Gupta VK & Paul YS. 2001. *Diseases of Vegetable Crops*. Kalyani Publ., New Delhi
- Sherf AF & Mcnab AA. 1986. *Vegetable Diseases and their Control*.Wiley InterScience, Columbia.
- Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.
- Gupta SK & Thind TS. 2006. *Disease Problem in Vegetable Production*.Scientific Publ., Jodhpur.6
- Walker JC. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

PPATH 526

Ecology of Soil-Borne Plant Pathogens

3(2+1)

Objective

To provide knowledge on soil-plant disease relationship.

Theory

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

Practical

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms. Isolation and identification of different biocontrol agents.

Lectures schedule: Theory

S. No.	Topic	No. of lecture(s)
1.	General Introduction.	1
2.	Soil as environment for plant pathogens	2
3.	Nature and importance of rhizosphere.	2
4.	Nature and importance of rhizoplane.	2
5.	Host exudates	2
6.	Soil and root inhabiting fungi	2
7.	Types of bio-control agents	2
8.	Inoculum potential	2
9.	Host and soil variables	2
10.	Concept of competition	2
11.	Predation	2
12.	Antibiosis and fungistasis.	8
13.	Biological control –Concepts and potentialities for managing soil-borne pathogens	2
14.	Suppressive and conducive soils	1

Lectures schedule: Practical

S. No.	Topic	No. of
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		lectures
1.	Isolation and enumeration of organisms in soil	1
2.	Soil dilution plate method	2
3.	Isolation from rhizosphere	2
4.	Isolation of <i>Trichoderma</i>	1
5.	Isolation of bacteria from soil.	2
6.	Pathogenicity test by soil inoculation technique. Cont.	2
7.	Pathogenicity test by seed I inoculation technique.Cont.	2
8.	Correlation between inoculum density of test pathogens and disease incidence. Cont.	2
9.	Demonstration of fungistasis natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms, Cont.	2

Suggested Readings

- Baker KF & Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.
- Cook RJ & Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.
- Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press, Cambridge, New York.
- Hillocks RJ & Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CAB International, Wallington.
- Parker CA, Rovira AD, Moore KJ & Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

PPATH 531

Plant Virology

3(2+1)

Objective

To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory

History of plant viruses, composition and structure of viruses. Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship. Virus nomenclature and classification, genome organization, replication and movement of viruses. Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics. Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultramicrotome. Origin and evolution, mechanism of resistance, genetic engineering, ecology, and listing of important diseases and their management.

Practical

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultramicrotomy, PCR.

Lectures schedule: Theory

S. No.	Topic	No. of lecture(s)
1	History of plant viruses	1
2	Composition and structure of viruses	2
3	Symptomatology of important plant viral diseases	1
4	Transmission of important plant viral diseases	2
5	Chemical properties of viruses	1
6	Physical properties of viruses	1
7	Host virus interaction	1
8	Virus vector relationship	1
9	Virus nomenclature and classification	4
10	Genome organization of viruses	1

11	Replication and movement of viruses	2
12	Isolation and purification of viruses	2
13	Electron microscopy	1
14	Protein and nucleic acid based diagnostics	2
15	Mycoviruses, phytoplasma arbo- and baculoviruses	1
16	Satellite viruses, satellite RNAs, phages,	1
17	viroids, prions	1
18	Principles of the working of electron microscope and ultra-microtome	1
19	Origin and evaluation, mechanism of resistance, genetic engineering and ecology	4
20	Listing of important diseases and their management	2

Lectures schedule: Practical

S. No.	Topic	
1	Study of symptoms caused by viruses	1
2	Transmission of viruses	2
3	Assay of viruses	2
4	Physical properties of viruses	2
5	Purification of viruses	2
6	Methods of raising anti-sera	1
7	Serological tests	2
8	Electron microscopy	1
9	Ultratomy	1
10	PCR	2

Suggested Readings

- Bos L. 1964. Symptoms of Virus Diseases in Plants. Oxford & IBH., New Delhi.
 Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ & Watson L. 1995. Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
 Gibbs A & 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.

PPATH -532

Principles of Plant Disease Management

3(2+1)

Objectives

To acquaint with different strategies for management of plant diseases.

Theory

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management. Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures. History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

Practical

In vitro and in vivo evaluation of chemicals and bioagents against plant pathogens; ED and MIC values, study of structural and functional details of sprayers and dusters.

Lectures schedule: Theory

S. No.	Topic	No. of lecture(s)
1	Principles of plant disease management by cultural methods	2
2	Principles of plant disease management by physical methods	2
3	Principles of plant disease management by biological methods	3
4	Principles of plant disease management by chemical methods	3
5	Principles of plant disease management by organic amendments	2

6	Principles of plant disease management by botanicals	2
7	Integrated control measures of plant diseases	2
8	Disease resistance and molecular approach for disease management	2
9	Foliage, seed and soil application of chemicals	2
10	Role of stickers, spreaders and other adjuvants	2
11	Health vis-à-vis environmental hazards	1
12	Residual effects and safety measures	1
13	History of fungicides, bactericides, antibiotics	1
14	Concepts of pathogen, immobilization	1
15	Chemical protection and chemotherapy	1
16	Nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals	6

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1	<i>In vitro</i> evaluation of chemicals against plant pathogens	4
2	<i>in vivo</i> evaluation of chemicals against plant pathogens	4
3	ED values	2
4	MIC values	2
5	Study of structural details of sprayers	2
6	Study of structural details of dusters	2

Suggested Readings

- Fry WE. 1982. Principles of Plant Disease Management. Academic Press, New York.
Hewitt HG. 1998. Fungicides in Crop Protection. CABI, Wallington.
Marsh RW. 1972. Systemic Fungicides. Longman, New York.
Nene YL & Thapliyal PN. 1993. Fungicides in Plant Disease Control. Oxford & IBH, N Delhi.
Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer-Verlag, New York.
Vyas SC. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PPATH -533

Diseases of Field and Medicinal Plants

3(2+1)

Objective

To educate about the nature, prevalence, etiology, factors affecting disease development and control measures of field and medicinal crop diseases caused by fungal, bacterial and viral diseases.

Theory

Diseases of Cereal crops- wheat, barley, rice, pearl millet, sorghum and maize. Diseases of Pulse crops- gram, urdbean, mothbean, mungbean, lentil, pigeonpea, soybean. Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor. Diseases of Cash crops- cotton, sugarcane. Diseases of Fodder legume crops- berseem, oats, guar, lucerne, cowpea. Medicinal crops- plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera.

Practical

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops.

Lectures schedule: Theory

S. No.	Topic	No. of lecturers
1.	General introduction	1
2.	Diseases of wheat.	4
3.	Diseases of barley. sugarcane	1
4.	Diseases of rice	3
5.	Diseases of pearl millet	1
6.	Diseases of sorghum and maize.	2
7.	Diseases of gram	2

8.	Diseases of urdbean, mothbean, mungbean, and lentil.	2
9.	Diseases of pigeonpea and soybean	2
10.	Diseases of rapeseed and mustard, linseed and sesame.	2
11.	Diseases of sunflower, and castor.	1
12.	Diseases of groundnut.	1
13.	Diseases of cotton	1
14.	Diseases of.	2
15.	Diseases of berseem, Lucerne and oats.	1
16.	Diseases of cowpea and guar	1
17.	Diseases of plantago, liquorice and mulathi	2
18.	Diseases of rosagrass, sacred basil and menthe.	2
19.	Diseases of ashwagandha and Aloe vera	1

Lectures schedule: Practical

1.	Study of symptoms and host parasite relationship of diseases of wheat.	2
2.	Study of symptoms and host parasite relationship of diseases of barley.	1
3.	Study of symptoms and host parasite relationship of diseases of pearl millet.	1
4.	Study of symptoms and host parasite relationship of diseases of sorghum & Maize.	1
5.	Study of symptoms and host parasite relationship of diseases of gram.	1
6.	Study of symptoms and host parasite relationship of diseases of mothbean & Mung.	1
7.	Study of symptoms and host parasite relationship of diseases of mustard.	1
8.	Study of symptoms and host parasite relationship of diseases of linseed.	1
9.	Study of symptoms and host parasite relationship of diseases of castor.	1
10.	Study of symptoms and host parasite relationship of diseases of groundnut.	1
11.	Study of symptoms and host parasite relationship of diseases of cotton.	1
12.	Study of symptoms and host parasite relationship of diseases of fodder legumes and medicinal plants.	2
13.	Collection and dry preservation of diseased specimens of important crops.	2

Suggested Readings

- Joshi LM, Singh DV & 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, N Delhi.
- Ricanel C, Egan BT, Gillaspie Jr AG & Hughes CG. 1989. Diseases of Sugarcane, Major Diseases. Academic Press, New York.
- Singh RS. 2007. Plant Diseases. 8th Ed. Oxford & IBH, New Delhi.
- Singh US, Mukhopadhyay AN, Kumar J & Chaube HS. 1992. Plant Diseases of International Importance. Vol. I. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.
- Thind, T.S. 1998. Diseases of field Crops and their management. National Agril. Technology Information Centre, Ludhiana, India.

Ph.D. Programme

PPATH -611

Advanced Virology

3(2+1)

Objective

To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory

Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains. Immunoglobulin structure and functions of various domains, methods of immuno diagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction. Genome organization,

replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo- poty, bromo, cucummo, ilar and tospoviruses. Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions. Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture. Origin, evolution and inter-relationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance, nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

Lectures schedule: Theory

S. No.	Topic	No. of lecture(s)
1.	Introduction	1
2.	Mechanism of virus transmission by vector.	1
3.	Virus vector relationship	1
4.	Biomodal transmission	1
5.	Taxonomy of vectors and viruses, vector specificity for classes of viruses.	3
6.	Virus replication	1
7.	Virus assembly and architecture	1
8.	Variation and mutation of virus strains	1
9.	Immunoglobulin structure & functions of various domains	2
10.	Methods of immune diagnosis, hybridoma technology	2
11.	Use of monoclonal antibodies in identification of viruses and their strains, PCR	1
12.	Genome organization, replication & transcription and translational strategies of pararetroviruses and Gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-poty, cucummo, ilar and tospovirus.	4
13.	Virus induced gene, symptom expression, viroid and prions	1
14.	Molecular mechanism of host virus interactions and vector transmission.	1
15.	Genetic engineering with plant viruses	1
16.	Viral suppressors; RNAi dynamics and resistant genes.	2
17.	Viruses potential as vectors. Genetically engineered resistance, transgenic plants.	2
18.	Gene expression and regulation, viral promoters.	2
19.	Techniques and application of tissue culture.	2
20.	Origin, evolution and inter relationship with animal viruses.	2

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1.	Purification of viruses, SDS-PAGE for molecular weight determination,	2
2.	Production of polyclonal antiserum	1
3.	Purification of IgG and conjugate preparation .	1
4.	Serological techniques- DAS- ELISA and DAC- ELISA	2
5.	Vector transmission of white fly, aphid and grasshopper	2
6.	Hybridoma technology	2
7.	Methods for collection of vectors.	2
8.	Nucleic acid isolation techniques, DOT bolt, southern hybridization, probe preparation and autoradiology,	2
9.	PCR application and viral genome cloning, sequenceing annotation of genes.	2

Suggested Readings

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.

1.	Protein isolation	2
2.	DNA isolation	2
3.	RNA isolation	1
4.	Plasmid extraction	1
5.	Electrophoresis	2
6.	DNA electrophoresis	2
7.	Protein electrophoresis	2
8.	Bacterial transformation	2
9.	PCR analysis	2

Suggested Readings

- Chet I. 1993. *Biotechnology in Plant Disease Control*. John Wiley & Sons, N.York.
- Gurr S.J, Mc Pohersen M.J & Bowlos D.J. (Eds.). 1992. *Molecular Plant Pathology - A Practical Approach*. Vols. I & II, Oxford Univ. Press, Oxford.
- Mathew J.D. 2003. *Molecular Plant Pathology*. Bios Scientific Publ., UK.
- Ronald P.C. 2007. *Plant-Pathogen Interactions: Methods in Molecular Biology*. Humana Press, New Jersey.
- Stacey G & Keen T.N. (Eds.). 1996. *Plant Microbe Interactions*. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

PPATH 621

Advanced Mycology

3(2+1)

Objective

To acquaint with the latest advances in Mycology.

Theory

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, Chemical (chemotaxonomy), Molecular and Numerical (Computer based assessment) taxonomy. Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi. Population biology, pathogenic variability/vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Practical

Study of conidiogenesis- phialides, porospores, arthospores. Study of fruit bodies in Ascomycotina. Identification of fungi up to species level. Study of hyphal anastomosis. Morphology of representative plant pathogenic genera from different groups of fungi.

Lectures schedule: Theory

S. No.	Topic	No. of lectures
1.	General Introduction.	1
2.	Historical development and advances in mycology.	2
3.	Recent taxonomic criteria, morphological criteria for classification.	3
4.	Serological, chemical(Chemotaxonomy), molecular and numerical(Computer based assessment) taxonomy.	4
5.	Interaction between groups: Phylogeny	2
6.	Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti	2
7.	Morphology and reproduction of representative plant pathogenic genera from different groups of fungi.	6
8.	Sexual reproduction in different groups of fungi.	2
9.	Population biology, pathogenic variability/ vegetative compatibility.	2
10.	Heterokaryosis and parasexual cycle.	2
11.	Sex hormone in Fungi.	1
12.	Pleomorphism and speciation in fungi.	2
13.	Mechanism of nuclear inheritance.	1

14.	Mechanism of extra nuclear inheritance.	1
15.	Biodegradation.	1

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1.	Study of conidiogenesis-phialides, porosporus, arthospores.	1
2.	Study of fruit bodies in Ascomycotina.	2
3.	Identification of fungi up to species level.	2
4.	Study of hyphal anastomosis.	1
5.	Study of morphology of important representative plant pathogenic genera of order Peronosporales	2
6.	Study of morphology of important representative plant pathogenic genera of order Erysiphales	2
7.	Study of morphology of important representative plant pathogenic genera of order Uredinales.	2
8.	Study of morphology of important representative plant pathogenic genera of order Ustilaginales.	2
9.	Study of morphology of important representative plant pathogenic genera of Deuteromycotina.	2

Suggested Readings

Alexopoulos CJ, Mimms CW & 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 & Stalpers JA. (Eds.). 2001. Ainsworth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington.

Ulloa M & Hanlin RT. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Mennisota.

Webster J & Weber R. 2007. Introduction to Fungi. Cambridge Univ. Press, Cambridge

PPATH 622

Advanced Bacteriology

3(2+1)

Objective

To provide knowledge about the latest advances in phytobacteriology.

Theory

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria. Current trends in taxonomy of phytopathogenic procarya.

Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development. Mechanism of wilt (*Ralstonia solanacearum*) development, mechanism of soft rot (*Erwinia* spp.) development, mechanism of Crown gall formation (*Agrobacterium tumifaciens*). Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, Effector protein. Molecular variability among phytopathogenic procarya and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pathogens-gene silencing, RNAi technology. Epidemiology in relation to bacterial plant pathogens. Development of diagnostic kit. Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

Practical

Pathogenic studies and race identification; plasmid profiling of bacteria; fatty acid profiling of bacteria; RAPD profiling of bacteria and variability status; Endospore, Flagiler staining; test for secondary metabolite production, cyanides, EPS, siderophore; specific detection of phytopathogenic bacteria using species/pathovar specific primers. Basic techniques in diagnostic kit development, molecular tools to identify phytoendosymbionts.

Lectures schedule: Theory

S. No.	Topic	No. of lectures
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1.	General Introduction.	1
2.	Current approaches for the characterization and identification of phytopathogenic bacteria.	2
3.	Ultrastructures and biology of bacteria.	2
4.	Current trends in taxonomy of phytopathogenic procarya.	2
5.	Role of enzyme, toxin, exopolysaccharide, and polypeptide signals in disease development.	3
6.	Mechanism of wilt (<i>Ralstonia solanacearum</i>)development	1
7.	Mechanism of soft rot (<i>Erwinia</i> spp.)development	1
8.	Mechanism of crown gall formation (<i>Agrobacterium tumifaciens</i>)	1
9.	Host bacterial pathogen interaction.	2
10.	Quorum-sensing phenomenon	1
11.	Type III secretion system	1
12.	R-genes	1
13.	Avr genes	1
14.	hrp genes	1
15.	Effector protein.	1
16.	Molecular variability among phytopathogenic procarya and possible host defense mechanism	2
17.	Genetic engineering for management of bacterial plant pathogens-gene silencing, RNAi technology.	2
18.	Epidemiology in relation to bacterial plant pathogens.	2
19.	Development of diagnostic kit.	2
20.	Beneficial prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in diseasemanagement.	2
21.	Endosymbionts for host defence.	1

Lectures schedule: Practical

S. No.	Topic	No. of lectures
1.	Study on pathogenic race identification.	1
2.	Study on Plasmid profiling of bacteria	1
3.	Study on Fatty acid profiling of bacteria	2
4.	Study on RAPD profiling of bacteria and variability status.	1
5.	Study on endospore and Flagler staining	2
6.	Test for secondary metabolite production, cyanides, EPS, siderophore.	3
7.	Specific detection of phytopathogenic bacteria using species/pathovar specific primers.	2
8.	Basic techniques in diagnostic kit development	2
9.	Molecular tools to identify phytoendosymbionts.	2

Suggested Readings

- Dale J.W & Simon P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York.
- Garrity G.M, Krieg N.R & Brenner D.. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.
- Gnanamanickam S.S. 2006. Plant-Associated Bacteria. Springer Verlag, New York.
- Mount M.S & Lacy G.H. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, N.Y.
- Sigee D.C. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge.
- Starr M.P. 1992. The Prokaryotes. Vols. I – IV. Springer Verlag, New York.

List of Journals

- Annals of Applied Biology* – Cambridge University Press, London
- Annual Review of Phytopathology* – Annual Reviews, Palo Alto, California
- Annual Review of Plant Pathology* - Scientific Publishers, Jodhpur
- Canadian Journal of Plant Pathology* - Canadian Phytopathological Society, Ottawa

- Indian Journal of Biotechnology* - National Institute of Science Communication and Information Resources, CSIR, New Delhi
- Indian Journal of Mycopathological Research*- Indian Society of Mycology, Kolkata.
- Indian Journal of Virology* - Indian Virological Society, New Delhi
- Indian Phytopathology* - Indian Phytopathological Society, New Delhi
- Journal of Mycology and Plant Pathology* - Society of Mycology and Plant Pathology, Udaipur
- Journal of Phytopathology* - Blackwell Verlag, Berlin
- Mycologia* - New York Botanical Garden, Pennsylvania
- Mycological Research* - Cambridge University Press, London
- Physiological Molecular Plant Pathology* - Academic Press, London
- Phytopathology* - American Phytopathological Society, USA
- Plant Disease* - The American Phytopathological Society, USA
- Plant Disease Research* – Indian Society of Plant Pathologists, Ludhiana
- Plant Pathology* - British Society for Plant Pathology, Blackwell Publ.
- Review of Plant Pathology* - CAB International, Wallingford
- Virology*- New York Academic Press

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- www.annual-reviews.org

PLANT PHYSIOLOGY

Course Structure

Course No.	Course Title	Credit hrs
1st Semester		
PPHYS 511*	Principles Of Plant Physiology	3+0
PPHYS 512*	Plant Water Relationship	2+1
PPHYS 513*	Techniques In Plant Physiology	2+1
2nd Semester		
PPHYS 521*	Physiological And Molecular Responses Of Plants To Biotic Stresses	2+1
PPHYS 523*	Seed Physiology	2+1
PPHYS 524*	Mineral Nutrition	3+0
3rd Semester		
PPHYS 531*	Hormonal Regulation Of Plant Growth And Development	2+1
PPHYS 532*	Physiological And Molecular Aspects Of Photosynthesis- Carbon And Nitrogen Assimilation	2+1
PPHYS 533*	Post Harvest Physiology	2+1
All Semester		
PPHYS 541*	Comprehensive	2
PPHYS 542*	Master's Seminar	1
PPHYS 543*	Master's Research	15

*Presently these courses will be offered to M.Sc. students

PPHYS 511**Principles of Plant Physiology****3(3+0)****Objective**

To acquaint the students with the basic concepts of plant physiology and their application in agriculture.

Theory

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions. Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration – Driving force for transpiration, plant factors influencing transpiration rate, Mycorrhizal association on water uptake. Stomata structure and function – mechanism of stomatal movement, antitranspirants. Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance. Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants. The role of mineral nutrients in plant metabolism, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition. Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO₂ reduction in Calvin cycle, supplementary pathway of C fixation in C₄ and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates, Translocation of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism: Inorganic nitrogen species (N₂, NO₃ and NH₃) and their reduction to aminoacids, protein synthesis and nucleic acids. Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominance, senescence, fruit growth, abscission. Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering-Photoperiodism and Vernalisation.

Lecture schedule---Theory

S.No	Topic	No. of lectures
1	Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.	3
2	Soil and plant water relations, water and its role in plants, properties and functions of water.	2
3	Water relations-cell water terminology, water potential of plant cells.	2
4	Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration .	2
5	Transpiration –Driving force for transpiration, plant factors influencing transpiration rate, Mycorrhizal association on water uptake.	2
6	Stomata structure and function – mechanism of stomatal movement	2
7	Antitranspirants.	2
8	Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.	2
9	Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.	2
10	The role of mineral nutrients in plant metabolism, critical levels, deficiency symptoms, nutrient deficiency and toxicity.	3
11	Foliar nutrition	1
12	Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions,	2
13	CO ₂ reduction in Calvin cycle, supplementary pathway of C fixation in C ₄ and CAM plants and its significance	3
14	Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates	3

15	Translocation of photosynthates and its importance in sink growth	2
16	Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.	3
17	Nitrogen metabolism: Inorganic nitrogen species (N ₂ , NO ₃ and NH ₃) and their reduction to aminoacids,	2
18	Protein synthesis and nucleic acids.	2
19	Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role.	2
20	Synthetic growth regulators, growth retardants., Apical dominance, senescence, fruit growth, abscission.	2
21	Photo-morphogenesis: Photo receptors, phyto-chrome, crypto-chrome,	2
22	Physiology of flowering- Photo-periodism and Vernalisation.	2

Suggested Readings

- Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
 Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
 Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
 Gupta N K & Gupta S. 2005. *Plant Physiology*. Oxford and IBH, New Delhi

PPHYS 512

Plant Water Relationship

3(2+1)

Objective

To acquaint the students within modern concepts of relationships of plants and water in relation to crop and plant productivity.

Theory

Properties of water and aqueous system solutions, colloids, unique and colligative properties. Movement of water in soil-plant atmosphere continuum (SPAC), Various resistances, Water relations of an individual cell-old and new terminology, water potential and inter-relationships among components. Methods of measurement of parameters of plant water relationships. Water absorption, Ascent of sap, Transpiration, physical and biological components. Physiological and ecophysiological aspects of stomatal movement, Antitranspirants, Water deficit and its effect on plant processes.

Practical

Measurement of relative water content, water potential, osmotic potential, rate of transpiration, Stomatal aperture and Stomatal frequency, computation of turgor potential, potential evapotranspiration, vapour pressure deficit.

Lecture schedule---Theory

S.No.	Topic	No. of lectures
1	Properties of water	1
2	Properties of aqueous system solutions, colloids, unique and colligative properties	2
3	Movement of water in soil-plant atmosphere continuum (SPAC)	3
4	Various resistances	2
5	Water relations of an individual cell-old and new terminology,	2
6	Water potential and inter-relationships among components.	2
7	Methods of measurement of parameters of plant water relationships.	3
8	Water absorption	3
9	Ascent of sap	3
10	Transpiration, physical and biological components	3
11	Physiological and ecophysiological aspects of stomatal movement	3
12	Antitranspirants	2
13	Water deficit and its effect on plant processes	3

Lecture schedule---Practical

S.No.	Topic	No. of lectures
1	Measurement of relative water content	2
2	Measurement of water potential and osmotic potential	4
3	Measurement of rate of transpiration, Stomatal aperture	3
4	Measurement of Stomatal frequency	2
5	Computation of turgor potential,	3
6	Evapotranspiration and vapour pressure deficit	2

Suggested Readings

1. P.J. Kramer 1983. Water relations of plants. Academic Press. New York and London.
2. O.I. Lange, I. Kappen and E.D. Schulze 1976. Water and Plant Life, Springer, Verlag-Berlin and New York.
3. F.B. Salisbury and C.W. Ross 1992. Plant Physiology, Tompson Information Publishing Group Colorado, USA.
4. Gupta N K & Gupta S. 2005. Plant Physiology. Oxford and IBH, New Delhi
5. B. Slavik 1974. Methods in Plant Water Relations, Springer-Verlag, Berlin and New York.
6. Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PPHYS-513**Techniques in Plant Physiology****3(2+1)****Objective**

To impart recent practical training to study various physiological processes in plants.

Theory

Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO₂ response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes. Radio isotopes in plant biology. Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants. Methods to phenotype germplasm for specific physiological traits. Quantification of mineral nutrients using advanced instruments like AAS, & ICP. Techniques in plant transformation & analysis of transgenic plants. Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLS. Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

Practical

Photosynthetic gas exchange measurements, chlorophyll fluorescence measurements (with the condition that suitable instrument is provided in the department), Estimation of water use efficiency at whole plant and single leaf level. DNA & RNA isolation. Preparation of solutions and buffers, estimation of carbohydrates (reducing and non-reducing sugars), determination of proteins, measurement of electrical conductivity.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO ₂ response curves	2
2	Determination of relative limitations to photosynthesis	1
3	chlorophyll fluorescence measurements	1
4	Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.	3
5	Radio isotopes in plant biology.	3

6	Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants	4
7	Methods to phenotype germplasm for specific physiological traits.	3
8	Quantification of mineral nutrients using advanced instruments like AAS, & ICP.	3
9	Techniques in plant transformation	3
10	Analysis of transgenic plants	2
11	Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLs	4
12	Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphorimager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.	3

Lecture schedule---Practical

S.No.	Topic	No. of lectures
1	Photosynthetic gas exchange measurements	2
2	Chlorophyll fluorescence measurements (with the condition that suitable instrument is provided in the department)	3
3	Estimation of water use efficiency at whole plant and single leaf level	2
4	Preparation of solutions and buffers	2
5	Isolation of DNA and RNA	2
6	Estimation of carbohydrates (reducing and non-reducing sugars)	2
7	Determination of proteins	2
8	Measurement of electrical conductivity	1

Suggested Readings

Dhopte MA & Manuael Livera M. 1986. *Useful Techniques for Plant Scientists*. Forum for Plant Physiologists, R. D. G., Aloka.

Bala M, Gupta S, Gupta N K , Sanga MK 2013. *Practicals in Plant Physiology and Biochemistry*. Scientific Publishers, Jodhpur.

PPHYS 521 Physiological and Molecular Responses of Plants to Abiotic Stresses 3(2+1)

Objective

To apprise the students regarding abiotic stress to plant and its molecular basis.

Theory

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses. Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmo-protectants, Stress proteins. Water use efficiency as a drought resistant trait. Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products. Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.). High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's. Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance. Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phyto-chelatin (heavy metal binding proteins).

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Stress imposition and quantification, Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use – efficiency, Heat and salt tolerance and membrane integrity.

Lecture schedule--Theory

S. No.	Topic	No. of lectures
1	Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity.	2
2	Basic principles of a crop improvement programme under stress,	2
3	Interactions between biotic and abiotic stresses.	1
4	Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance),	2
5	Dehydration tolerance and characteristics of resurrection plants.	1
6	Osmotic adjustment, Osmo-protectants, Stress proteins. Water use efficiency as a drought resistant trait.	2
7	Molecular responses to water deficit: Stress perception,	2
8	Expression of regulatory and functional genes and significance of gene products.	1
9	Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress:	3
10	Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).	3
11	High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.	3
12	Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms.	3
13	Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance.	2
14	Heavy metal stress: Aluminum and cadmium toxicity in acid soils.	3
15	Role of Phyto-chelatins (heavy metal binding proteins).	2

Lecture schedule--Practical

S. No.	Topic	No. of lectures
1	Measurement of water status of plants	3
2	Determination of osmotic potential by vapour pressure and freezing point depression	2
3	Stress imposition and quantification,	2
4	Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity	3
5	Water use – efficiency	2
6	Heat and salt tolerance	2
7	Membrane integrity	2

Suggested Readings

- Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
 Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
 Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
 Gupta N K & Gupta S. 2005. *Plant Physiology*. Oxford and IBH, New Delhi.

Objective

To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

Theory

Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development. Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion. Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds. Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored resources, Role of embryonic axes, Gibberellin and α -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins. Seed viability, Physiology of and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, Seed dormancy, types and regulation, means to overcome seed dormancy.

Practical

Determination of seed storage proteins, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced amylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed ardening/osmotic priming of seeds, Seed respiration rates, Seed viability losses through membrane leakage studies.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion.	3
2	Hereditary and environmental effect on seed development. Gene imprints and seed development.	2
3	Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences,	3
4	Physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.	3
5	Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds	2
6	Storage of carbohydrates, proteins and fats in seeds	2
7	Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds	3
8	Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.	2
9	Control processes in mobilization of stored resources, Role of embryonic axes, Gibberellins and α -amylase and other hydrolytic activity.	3
10	Seed maturation phase and desiccation damage, Role of LEA proteins.	2
11	Seed viability, Physiology of and means to prolong seed viability,	2
12	Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it,	2
13	Seed dormancy, types and regulation	2
14	Means to overcome seed dormancy	1

Lecture schedule—Practical

S.No.	Topic	No. of lectures
1	Determination of seed storage proteins	2

2	Alpha-amylase activity in germinating seeds	2
3	Role of GA in inducing amylase activity	2
4	Role of embryo in GA induced amylase activity	2
5	Protease and lipase activity in germinating seeds	2
6	Seed viability test and accelerated ageing test	2
7	Seed ardening/osmotic priming of seeds	2
8	Seed respiration rates	1
9	Seed viability losses through membrane leakage studies	1

Suggested Readings

Bewley JD & Black M. 1985. *Seed Physiology of Development and Germination*. Plenum Publ. opeland

LO & McDonald MB. *Principles of Seed Sciences and Technology*. Burgers Publ. Co.

Srivastav L M. 1995. *Plant Growth and Development - Hormones and Environment*, Academic Press.

PPHYS-524

Mineral Nutrition

3 (3+0)

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation

Theory

Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system. Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity. Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation. Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels. Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Sulphur, Iron and Zinc efficient crop varieties.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Overview of essential mineral elements,	3
2	Kinetics of nutrient uptake by plants.	3
3	Biological actions influencing nutrient availability near the root system.	3
4	Nutrient uptake by root cells,	2
5	Long distance transport of nutrients in plants and movement into developing grains.	3
6	Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.	4
7	Molecular mechanism of ion uptake,	3
8	Ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients.	2
9	Multiple transporters for a single ion and their functional regulation.	5
10	Molecular physiology of micronutrient acquisition.	4

11	Examples of genes encoding mineral ion transporters.	3
12	Strategies plants adopt to acquire and transport minerals under deficient levels.	3
13	Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes	5
14	Examples of Phosphorous, Sulphur, Iron and Zinc efficient crop varieties.	5

Suggested Readings

Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC
 Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.
 Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.Press.

PPHYS 531 Hormonal Regulation of Plant Growth and Development 3(2+1)

Objective

To apprise the students about structure function of plant growth regulator on growth and development of plant.

Theory

Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. triconanol, Phenols – polyamines, jasmonates, concept of death hormone.Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene Brassinosteroids. Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening. Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings- Flowering. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practical

Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect onrooting of cuttings, abscission, apical dominance, Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin- bioassays- cytokinin effect on apical dominance and senescence, ABA bioassayestimation. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico chemical techniques (with the condition that GLC/ HPLC is provided) - effect of hormones on breaking dormancy.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Definition and classification of plant growth regulators- Hormones,	2
2	Endogenous growth substances and synthetic chemicals	2
3	Endogenous growth regulating substances other than hormones. triconanol, Phenols – polyamines, jasmonates, concept of death hormone.	3
4	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth and development of individual group of hormones- Auxins	1
5	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth and development of individual group of hormones- Gibberlins	1
6	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- and cytokinins	1
5	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth and development of individual group of hormones-. Abscisic acid	1
5	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth and development of individual group of hormones- Ethylene	1
5	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth	2

	and development of individual group of hormones- brassinosteroids	
8	Signal perception. Transduction and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds.	3
9	Signal perception. Transduction and effect at functional gene level of different hormones- cytokinins- cell division. Retardation of senescence of plant parts, Absciscic acid- Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.	3
7	Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance,	3
8	Molecular aspects of control of reproductive growth and development.	3
9	Synthetic growth regulators- Classification, their effect on plant growth and development.	3
10	Practical utility of Synthetic growth regulators agriculture and horticulture.	3

Lecture schedule--Practical

S.No.	Topic	No. of lectures
1	Extraction of hormones from plant tissue.	5
2	Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance	2
3	Gibberellins- bioassays-GA effect on germination of dormant seeds,	2
4	Cytokines- bioassays- cytokinin effect on apical dominance and senescence,	2
5	ABA bioassays estimation. ABA effect on stomatal movement,	2
6	Ethylene bioassays, effect of hormones on breaking dormancy	2
7	Estimation of PGRs using physico chemical techniques (with the condition that GLC/ HPLC is provided)	3

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

PPHYS 532 Physiological and Molecular Aspects of Photosynthesis-Carbon and Nitrogen Assimilation 3(2+1)

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere. Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield. Photosynthetic carbon reduction cycle and its regulation. CO₂ Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C₄, CAM and single celled C₄ organisms, C₃-C₄ intermediates. Ecological significance of CCM. Rubisco structure, assembly and kinetics, photorespiration and its significance. Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of r_a, r_s and r_m. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc. Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C₄ photosynthesis genes in C₃ species. Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and non-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept. Prospects of improving photosynthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches. Nitrogen assimilation in

photosynthesizing cells – NO₃⁻, NO₂⁻ reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

Practical

Extraction and separation of plant pigments, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates –gas exchange. A, gs, Ci, A/g_s, C/g_s- intrinsic WUE by gas exchange rates. Light, CO₂, VPD response curves, Determination of photorespiration by gas exchange- (with the condition that suitable equipments are provided in the department). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Photosynthesis-its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.	3
2	Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids,	3
3	Photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.	2
4	Photosynthetic carbon reduction cycle and its regulation.CO ₂ Concentration Mechanism (CCM) as a complementary strategy for carbon fixation.CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C ₄ , CAM and single celled C ₄ organisms, C ₃ -C ₄ intermediates.	3
5	Ecological significance of CCM.	1
6	Rubisco structure, assembly and kinetics. Photorespiration and its significance.	2
7	Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export.	3
8	Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.	2
9	Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes regulating potential traits of photosynthesis,	2
10	Biotechnological approaches for improving photosynthetic rate and productivity–transgenics. Conceptual approaches of expressing C ₄ photosynthesis genes in C ₃ species.	2
11	Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms.	2
12	Photochemical and no-photochemical quenching of chlorophyll fluorescence.	1
13	Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.	2
14	Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches.	2
15	Nitrogen assimilation in photosynthesizing cells – NO ₃ ⁻ , NO ₂ ⁻ reduction, GS-GOGAT pathway.	1
16	Photorespiration loss of Ammonia and its re-assimilation and WUE.	1

Lecture schedule--Practical

S.No.	Topic	No. of lectures
1	Extraction and separation of plant pigments	2
2	Enzymatic determination of starch and sucrose	4
3	Determination of photosynthetic rates –gas exchange	1
4	A, gs, Ci, A/g _s , C/g _s - intrinsic WUE by gas exchange rates. Light, CO ₂ , VPD response curves,	3
5	Determination of photorespiration by gas exchange- (with the condition that suitable equipments are provided in the department).	2

6	Genotypic/species differences in photosynthetic rates.	2
7	Measurement of radiation, Eu% light interception.	2

Suggested Readings

- Gupta N K & Gupta S. 2005. *Plant Physiology*. Oxford and IBH, New Delhi
 Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
 Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ. 92
 Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PPHYS-533

Post Harvest Physiology

3(2+1)

Objective

To impart knowledge about physiological changes during senescence and ripening.

Theory

Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds. Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products. Functional and ultrastructural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening. Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action. Post harvest changes in seed and tubers biochemical constituent's quality parameters. Effect of environmental factors on post harvest changes in seed and tubers. Biotechnological approaches to manipulate ethylene biosynthesis and action. Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits. Uses of GM crops and ecological risk assessment.

Practical

Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening (with the condition that GLC/ HPLC is provided in the department), determination of Reactive Oxygen Species and scavenging enzymes, Estimation of ripening related enzyme activity, Cellulases pectin methyl esterases, polygalacturonase etc.

Lecture schedule--Theory

S.No.	Topic	No. of lectures
1	Environmental factors influencing senescence	2
2	Ripening and post harvest life of flowers, vegetables and seeds.	2
3	Molecular mechanism of senescence and ageing.	2
4	Physiological, biochemical and molecular aspects of senescence and fruit ripening	3
5	Senescence associated genes and gene products.	3
6	Functional and ultra structural changes in chloroplast membranes	2
7	Mitochondria and cell wall during senescence and ripening.	2
8	Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action.	3
9	Post harvest changes in seed and tubers biochemical constituent's quality parameters.	2
10	Effect of environmental factors on post harvest changes in seed and tubers.	2
11	Biotechnological approaches to manipulate ethylene biosynthesis and action.	3
12	Alternate post harvest methodology and quality attributes.	2
13	Scope for genetic modification of post harvest life of flowers and fruits.	2
14	Uses of GM crops and ecological risk assessment.	2

Lecture schedule--Practical

S.No.	Topic	No. of lectures
1	Physiological and biochemical changes during senescence and ripening, ,	3
2	Estimation of ethylene during senescence and ripening (with the condition that GLC/ HPLC is provided in the department),	5
3	determination of Reactive Oxygen Species and scavenging enzymes	4

4	Estimation of ripening related enzyme activity, Cellulases pectin methyl esterases, polygalacturonase etc.	4
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Suggested Readings

Jeffrey K Brecht & Weichmann J. 2003. *Post Harvest Physiology and Pathology of Vegetables*. CRC Press.

List of Journals

- American Journal of Botany
- Annals of Arid Zone
- Annual Review of Plant Physiology and Plant Molecular Biology
- Australian Journal of Agricultural Research
- Australian Journal of Biological Sciences
- Australian Journal of Botany
- Australian Journal of Plant Physiology
- Biochemie und Physiologie der Pflanzen
- Biologia Plantarum
- Botanical Gazette
- Botanical Review
- Canadian Journal of Agricultural Research
- Canadian Journal of Botany
- Canadian Journal of Plant Science
- Communications in Soil Science and Plant Analysis
- Current Science
- Environmental and Experimental Botany
- Euphytica
- Experimental Agriculture
- Experimental Cell Biology
- Functional Plant Biology
- Indian Journal of Agriculture
- Indian Journal of Experimental Biology
- Indian Journal of Plant Physiology
- International Journal of Botany
- Japanese Journal of Crop Science
- Journal of Agricultural and Scientific Research
- Journal of Agricultural Science
- Journal of Arid Environment
- Journal of Experimental Botany
- Journal of Plant Biology
- Journal of Plant Nutrition
- Nature
- New Phytologist
- Physiologia Plantarum
- Physiology and Molecular Biology of Plants
- Plant and Cell Physiology
- Plant and Soils
- Plant Cell, Tissue and Organ Culture
- Plant Growth Regulator abstracts
- Plant Physiology and Biochemistry
- Plant Science

- Plant Science (India)
- Science Journal
- Seed Science and Technology
- Seed Science Research
- Soil Science and Plant Nutrition
- Soviet Plant Physiology
- Trends in Plant Science
- Tropical Agriculture

e-Resources

- www.Bioone Online Journals The Arabiopsis Book.
- www. Botany on line:
- www.Ingenta Connect Physiologia Plantarum
- www.new.phytologist.org.
- www.plantphysiol.org.
- www.mpiz-Kolen.mpg.de.
- www.Science Direct.
- www.Scientia Agricola.
- www.wiley interscience

SOIL SCIENCE & AG.CHEMISTRY

M. Sc. and Ph. D. (Soil Science)

SEMESTER WISE COURSES DISTRBUTION

S.NO	COURSE NO.	TITLE	Credit hrs.
M.Sc(Ag) I-Semester (Minimum 9 credits hrs.)			
1.	SOILS-511*	Soil chemistry	3(2+1)
2.	SOILS -512	Soil mineralogy, genesis, classification and soil survey	3(2+1)
3	SOILS -513	Analytical techniques and instrumental methods in soil and plant analysis	3(1+2)
II-Semester (Minimum 12 credits hrs.)			
4.	SOILS -521*	Soil fertility and fertilizer use	4(3+1)
5.	SOILS -522*	Soil biology and biochemistry	3(2+1)

6.	SOILS -524	Soil, water and air pollution	3(2+1)
7.	SOILS -525	Fertilizer technology	2(2+0)
III-Semester (Minimum 9 credits hrs.)			
8.	SOILS -531*	Soil physics	3(2+1)
9.	SOILS -532	Management of problem soils and waters	3(2+1)
IV-Semester			
10	SOILS -541	Seminar	1
11	SOILS -542	Comprehensive	2
12	SOILS -543	Research	15
Ph.D. I-Semester (Minimum 6 credits Hrs.)			
1.	SOILS -611*	Advances in soil fertility	3(2+1)
2	SOILS -612	Advances in soil physics	3(3+0)
3	SOILS -613	Physical chemistry of soils	3(3+0)
II-Semester (Minimum 6 credits Hrs.)			
4.	SOILS -621*	Biochemistry of soil organic matter	3(2+1)
5	SOILS -623	Land use planning and watershed management	3(3+0)
6	SOILS -624	Soil Genesis and micropedology	2(2+0)
All Semester			
7	SOILS -641	Seminar	2
8	SOILS -642	Preliminary	4
9	SOILS -643	Research	40

(* Compulsory / Core courses)

SOILS 511

Soil Chemistry

3(2+1)

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory

Chemical (elemental) composition of the earth's crust and soils, Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics, Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions, Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement; anion and ligand exchange – innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition, Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects, Chemistry of acid soils; active and potential acidity; lime potential; sub-soil acidity, Chemistry of salt-affected soils and amendments, Chemistry and electrochemistry of submerged soils.

Practical

Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH, meter and conductivity meter, Adsorption-desorption of phosphate/sulphate by soil using simple, adsorption isotherm, Determination of titratable acidity of an acid soil by BaCl₂-TEA method.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Chemical (elemental) composition of the earth's crust and soils.	1

2.	Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.	1
3.	Inorganic and organic colloids - origin of charge,	1
4.	Concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils;	2
5.	Diffuse double layer theories of soil colloids,	2
6.	Zeta potential,	2
7.	Stability, coagulation/flocculation and peptization of soil colloids;	2
8.	Eelectrometric properties of soil colloids	1
9.	Sorption properties of soil colloids;	1
10.	Fractionation of soil organic matter and different fractions, clay-organic interactions.	2
11.	Theories of cation exchange based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept,	2
12.	Clay-membrane electrodes and ionic activity measurement,;	1
13.	Anion and legend exchange – innersphere and outer-sphere surface complex formation	1
14.	Fixation of oxyanions,hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on legend exchange,	1
15.	AEC, CEC;	1
16.	Experimental methods to study ion exchange phenomena and practical implications in plant nutrition.	1
17.	Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.	3
18.	Chemistry of acid soils; active and potential acidity; lime potential,; sub-soil acidity	2
19.	Chemistry of salt-affected soils and amendments;	2
20.	Chemistry of submerged soils.	1
21.	Electrochemistry of submerged soils.	2

Lecture schedule—Practical

S. No	Topic	No. of lecture
1.	Determination of CEC of soils	2
2.	Determination of AEC of soils	2
3.	Analysis of equilibrium soil solution for pH	1
4.	Analysis of equilibrium soil solution for Eh	2
5.	Analysis of equilibrium soil solution for EC	1
6.	Adsorption-desorption of phosphate by soil using simple adsorption isotherm	3
7.	Adsorption-desorption of sulphate by soil using simple adsorption isotherm	3
8.	Determination of titratable acidity of an acid soil by BaCl ₂ -TEA method	2

Suggested Readings

- Bear RE. 1964. *Chemistry of the Soil*. Oxford and IBH.
- Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford Univ. Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.
- Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
- Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 512 Soil Mineralogy, Genesis, Classification And Survey

3(2+1)

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

Fundamentals of crystallography, isomorphism and polymorphism, Structural chemistry, Classification of minerals, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; amorphous soil constituents and other non-crystalline silicate minerals; clay minerals in Indian soils, Soil morphology and micromorphology, Factors of soil formation, soil forming processes, weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils, Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness, Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps, Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical

Identification of rocks and minerals, Morphological properties of soil profile in different landforms, Classification of soils using soil taxonomy, Grouping soils using available data base in terms of soil quality, Aerial photo and satellite data interpretation for soil and land use, Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales, Land use planning exercises using conventional and RS tools

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Fundamentals of crystallography, isomorphism and polymorphism	1
2.	Structural chemistry and Classification of minerals	1
3.	Chemical composition and properties of clay minerals	2
4.	Genesis and transformation of crystalline and non-crystalline clay minerals	2
5.	Amorphous soil constituents and other non-crystalline silicate minerals; clay minerals in Indian soils.	2
6.	Soil morphology and micromorphology	1
7.	Soil formation, Factors of soil formation, soil forming processes	2
8.	Weathering of rocks and mineral transformations	3
9.	Soil profile; weathering sequences of minerals with special reference to Indian soils	2
10.	Concept of soil individual and soil classification systems	2
11.	Historical developments and modern systems of soil classification with special emphasis on soil taxonomy	2
12.	Soil classification, soil mineralogy and soil maps – usefulness.	1
13.	Soil survey and its types; soil survey techniques - conventional and modern	2
14.	Soil series – characterization and procedure for establishing soil series	1
15.	Benchmark soils and soil correlations	1
16.	Soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps	2
17.	Landform – soil relationship; major soil groups of India with special reference to respective states	1
18.	Land capability classification and land Irrigability classification	1
19.	Land evaluation and land use type (LUT) – concept and application	2
20.	Approaches for managing soils and landscapes in the framework of agro-ecosystem.	1

Lecture schedule—Practical

S. No	Topic	No. of lecture
9.	Identification of rocks	1
10.	Identification of minerals	1
11.	Morphological properties of soil profile in different landforms	2
12.	Classification of soils using soil taxonomy	2
13.	Grouping soils using available data base in terms of soil quality	2
14.	Aerial photo and satellite data interpretation for soil and land use	2
15.	Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales	4
16.	Land use planning exercises using conventional and RS tools	2

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
- Dixon JB & Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.
- USDA. 1999. *Soil Taxonomy*. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA & Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy: II. The Soil Orders*. Elsevier.
- Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy. I. Concept and Interaction*. Elsevier.

SOILS 513 Analytical techniques and instrumental methods in soil and plant analysis 3(1+2)

Objective

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Theory

Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods.

Practical

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Electrochemical titration of clays; determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity, analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods, drawing normalized exchange isotherms; measurement of redox potential.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Principles of visible, ultraviolet and infrared spectrophotometry	2
2.	Principle and instrumentation of atomic absorption spectrophotometer	2
3.	Principles of flame-photometry	1
4.	Principles and instrumentation of inductively coupled plasma spectrometry	2
5.	Principles and instrumentation of chromatographic techniques	4
6.	Principles of mass spectrometry and X-ray diffractometry	2

7.	Principles of identification of minerals by X-ray by different methods.	3
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Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Analytical chemistry – Basic concepts, techniques and calculations	3
2.	Principle of analytical instruments and their calibration for soil and plant analysis	2
3.	Determination of available nitrogen in soil	1
4.	Determination of available phosphorus in soil	1
5.	Determination of available potassium in soil	1
6.	Determination of available sulphur in soil	1
7.	Determination of available Boron in soil	1
8.	Determination of available molybdenum in soil	1
9.	Determination of iron, copper, manganese and zinc in soil	1
10.	Determination of potential buffering capacity of phosphorus	1
11.	Determination of potential buffering capacity of potassium	1
12.	Determination of ammonium fixation capacity of soil	1
13.	Determination of potassium fixation capacity of soil	1
14.	Determination the cation exchange capacity of soil	1
15.	Determination the anion exchange capacity of soil	1
16.	Determination of calcium and magnesium in soil	1
17.	Determination of Sodium in soil	1
18.	Estimation of root cation exchange capacity	1
19.	Determination of nitrogen in plant	1
20.	Determination of phosphorus in plant	1
21.	Determination of potassium in plant	1
22.	Determination of sulphur in plant	1
23.	Determination of calcium and magnesium in plant	1
24.	Determination of boron in plant	1
25.	Determination of molybdenum in plant	1
26.	Determination of iron, copper, manganese and zinc in plant	1
27.	Estimation of root cation exchange capacity	1
28.	Drawing normalized exchange isotherms; measurement of redox potential	2

Suggested Readings

- Hesse P. 971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
 Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
 Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
 Kenneth Helrich 1990. *Official Methods of Analysis* Association of Official Analytical Chemists.
 Page AL, Miller RH & Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
 Piper CE. *Soil and Plant Analysis*. Hans Publ.
 Singh D, Chhonkar PK & Pandey RN. 1999. *Soil Plant Water Analysis – A Methods Manual*. IARI, New Delhi.
 Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
 Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Waters*. FDCO, New Delhi.
 Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

SOILS 521

Soil Fertility And Fertilizer Use

4(3+1)

Objective

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms, soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification,

denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency, soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions, potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions, sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers, micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability, common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions, fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management, soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical:

Chemical analysis of soil for total N,P&K and available nutrients (N, P, K, S, Cu, Fe, Mn ,Zn, Mo. B), analysis of plants for essential elements (N, P, K, S, Cu, Fe, Mn, Zn, Mo, B)

Lecture schedule—Theory

S. No.	Topic	No. of lecture
1.	Soil fertility and soil productivity	1
2.	Nutrient sources – fertilizers and manures	1
3.	Essential plant nutrients - functions and deficiency symptoms	2
4.	Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification	2
5.	Biological nitrogen fixation -types, mechanism, microorganisms and factors affecting	2
6.	Nitrogenous fertilizers and their fate in soils	2
7.	Management of nitrogenous fertilizer in lowland and upland conditions for high fertilizer use efficiency.	2
8.	Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils	2
9.	Factors affecting phosphorus availability in soils	1
10.	Phosphatic fertilizers - behavior in soils and management under field conditions.	2
11.	Potassium - forms, equilibrium in soils and its agricultural significance	1
12.	Mechanism of potassium fixation in soil	2
13.	Management of potassium fertilizers under field conditions	1
14.	Sulphur - source, forms, fertilizers and their behavior in soils	1
15.	Calcium and magnesium– factors affecting their availability in soils	2
16.	Management of sulphur, calcium and magnesium fertilizers under field conditions	2
17.	Micronutrients – critical limits in soils and plants	1
18.	Factors affecting their availability and correction of their deficiencies in plants	3
19.	Role of chelates in nutrient availability	1
20.	Common soil test methods for fertilizer recommendations	2
21.	Quantity– intensity relationships	1
22.	Soil test crop response correlations and response functions	2
23.	Fertilizer use efficiency and factors affecting the FUE	2
24.	Blanket fertilizer recommendations – usefulness and limitations	1
25.	Site-specific nutrient management	1
26.	Plant need based nutrient management	1
27.	Integrated nutrient management and its importance and components	1
28.	Soil fertility evaluation : Biological methods, use of visual symptoms of nutrient deficiency or toxicity	1
29.	Soil fertility evaluation : Plant analysis method – DRIS methods, critical levels in plants, rapid tissue tests, indicator plants	1
30.	Soil fertility evaluation: Soil analysis methods – critical levels of different nutrients in soil.	2

31.	Interpretation and calibration of soil test values and fertilizer recommendations to crops	1
32.	Soil quality in relation to sustainable agriculture	1

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Determination of Total nitrogen in soil	1
2.	Determination of Total phosphorus in soil	1
3.	Determination of Total potassium in soil	1
4.	Determination of available nitrogen in soil	1
5.	Determination of available phosphorus in soil	1
6.	Determination of available potassium in soil	1
7.	Determination of available sulphur in soil	1
8.	Determination of available Boron in soil	1
9.	Determination of available molybdenum in soil	1
10.	Determination of iron, copper, manganese and zinc in soil	1
11.	Determination of nitrogen in plant	1
12.	Determination of phosphorus in plant	1
13.	Determination of potassium in plant	1
14.	Determination of sulphur in plant	1
15.	Determination of boron in plant	1
16.	Determination of molybdenum in plant	1
17.	Determination of iron, copper, manganese and zinc in plant	1

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.
- Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.
- Troeh FR & Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

SOILS 522

Soil biology and Biochemistry

3(2+1)

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota, microbiology and biochemistry of root-soil interface; phyllosphere; rhizosphere, soil, enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora, microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients, biodegradation of organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil, preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost, biofertilizers – definition, classification, specifications, method of production and role in crop production, BIS standards for biofertilizer for quality control.

Practical

Determination of soil microbial population, soil microbial biomass (C N P), fractionation of organic matter (HA, FA, Humin, Lignin and humus) and functional groups, soil enzymes, measurement of important soil microbial processes such as nitrification, N₂ fixation, S oxidation, P solubilization .

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Soil microbiology, Soil biota, soil microbial ecology	1
2.	Classification of micro-organism and types of organisms in different soils	2
3.	Soil microbial biomass	1
4.	Microbial interactions	1
5.	Soil biota in culturale and un-culturale land and factors affecting it	1
6.	Microbiology and biochemistry of root-soil interface	2
7.	Phyllosphere	1
8.	Rhizoshpere	1
9.	Soil enzymes, origin, activities and importance	1
10.	Soil characteristics influencing growth and activity of microflora.	1
11.	Microbial transformations of nitrogen in soil	1
12.	Microbial transformations of Phosphorus in soil	1
13.	Microbial transformations of Sulphur in soil	1
14.	Microbial transformations of Iron in soil	1
15.	Microbial transformations of manganese in soil	1
16.	Biochemical composition and biodegradation of soil organic matter and crop residues	2
17.	Humus formation; cycles of important organic nutrients.	2
18.	Biodegradation of organic wastes and their use for production of biogas and manures	2
19.	Biotic factors in soil development	1
20.	Microbial toxins in the soil	1
21.	Preparation and preservation of farmyard manure and animal manure	1
22.	Composting methods and Rural and urban compost	1
23.	Vermicomposting	2
24.	Biofertilizers – definition, classification, specifications, method of production and role in crop production	2
25.	BIS standards for biofertilizer for quality control	1

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Determination of soil microbial population (Fungi, Bacteria and Actinomycetes)	2
2.	Determination of Soil microbial biomass Carbon	2
3.	Determination of Soil microbial biomass Nitrogen	2
4.	Determination of Soil microbial biomass phosphorus	2
5.	Fractionation of organic matter (HA, FA, Humin, Lignin and humus) and functional groups	4
6.	Measurement of important soil microbial processes such as nitrification, N ₂ fixation, S oxidation, P solubilization	4

Suggested Readings

- Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.
 Burges A & Raw F. 1967. *Soil Biology*. Academic Press.
 McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.
 Metting FB. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.
 Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.
 Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.
 Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill.
 Stotzky G & Bollag JM. 1993. *Soil Biochemistry*. Vol. VIII. Marcel Dekker.
 Sylvia DN. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.

SOILS 524

Soil, water and air pollution

3(2+1)

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

Soil, water and air pollution problems associated with agriculture, nature and extent, nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings, sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal, pesticides – their classification, behavior in soil and effect on soil microorganisms, toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health, Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide, remediation/amelioration of contaminated soil and water; soil as a sink for waste disposal, soil and water quality standards.

Practical

Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants, estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammonical nitrogen and phosphorus, heavy metal content in effluents, heavy metals in contaminated soils and plants, analysis of soil and plant samples for pesticides residues, visit to various industrial sites to study the impact of pollutants on soil and plants.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Soil, water and air pollution problems associated with agriculture, nature and extent	3
2.	Air pollution causes, effects and control	1
3.	Water pollution causes, effects and control	1
4.	Soil pollution causes, effects and control	1
5.	Nature and sources of agricultural pollutants and their CPC standards and effect on plants, animals and human beings	1
6.	Nature and sources of industrial pollutants and their CPC standards and effect on plants, animals and human beings	2
7.	Nature and sources of urban wastes pollutants and their CPC standards and effect on plants, animals and human beings	2
8.	Nature and sources of fertilizers and pesticides pollutants and their CPC standards and effect on plants, animals and human beings	2
9.	Nature and sources of pollutants as acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings	2
10.	Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal	3
11.	Pesticide and its classification	1
12.	Pesticides behavior in soil and effect on soil microorganisms	2
13.	Toxic elements – their sources, behavior and effect on soil	1
14.	Effect of toxic elements on nutrients availability and plant and human health	2
15.	Pollution of water resources due to leaching of nutrients and pesticides from soil	1
16.	Emission of greenhouse gases – carbon dioxide, methane and nitrous oxide	3
17.	Remediation/amelioration of contaminated soil and water	2
18.	Soil as a sink for waste disposal, soil and water quality standards.	2

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants	2
2.	Estimation of total dissolved and suspended solids heavy metal content in effluents	1
3.	Determination of chemical oxygen demand (COD) in effluents	1
4.	Determination of biological demand (BOD) in effluents	1
5.	Determination of nitrate nitrogen in effluents	1
6.	Determination of amonical nitrogen in effluents	1
7.	Determination of phosphorus in effluents	1
8.	Determination of heavy metal content in effluents	2
9.	Analysis of temporary and total hardness of water sample by titration	1
10.	Determination of heavy metal content in contaminated soil	3
11.	Determination of heavy metal content in plant samples	2

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect*. CRC Press.
 Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience.
 Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.
 Vesilund PA & Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

SOILS 525

Fertilizer technology

2(2+0)

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order, manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents, recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order, new and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states	3
2.	Fertilizer control order	2
3.	Manufacturing processes for nitrogenous fertilizers using various raw materials, characteristics and nutrient contents.	4
4.	Manufacturing processes for phosphatic fertilizers using various raw materials, characteristics and nutrient contents.	3
5.	Manufacturing processes for potassic fertilizers using various raw materials, characteristics and nutrient contents.	2
6.	Manufacturing processes for Secondary nutrients fertilizers using various raw materials, characteristics and nutrient contents.	2
7.	Manufacturing processes for micro nutrient fertilizers using various raw materials, characteristics and nutrient contents.	3
8.	Manufacturing processes for mix and complex fertilizers using various raw materials, characteristics and nutrient contents.	3
9.	Recent developments in secondary and micronutrient fertilizers and their quality control as	2

	per fertilizer control order	
10.	New and emerging issues in fertilizer technology	2
11.	New and emerging issues in production and use of slow and controlled release fertilizers	3
12.	Supergranules fertilizers	1
13.	fertilizers for specific crops/situations and applications	2

Suggested Readings

- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. Pearson Edu.
Fertilizer (Control) Order, 1985 and the Essential Commodities Act. FAI, New Delhi.
 Kanwar JS. (Ed.). 1976. *Soil Fertility: Theory and Practice*. ICAR.
 Olson RA, Army TS, Hanway JJ & Kilmer VJ. 1971. *Fertilizer Technology and Use*. 2nd Ed. Soil Sci. Soc. Am. Madison.
 Prasad R & Power JF. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
 Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers*. McMillan Publ. Vogel AI. 1979. *Textbook of Quantitative Inorganic Analysis*. ELBS.

SOILS 531

Soil Physics

3(2+1)

Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system, soil texture, textural classes, mechanical analysis, specific surface, soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts, soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation, soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential, water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils, infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum, composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management, modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

Mechanical analysis by pipette and international methods, determination of bulk density of soil by core sampler method, measurement of Atterberg limits, aggregate analysis - dry and wet, measurement of soil-water content by different methods, measurement of soil-water potential by using tensiometer and gypsum blocks, determination of soil-moisture characteristics curve and computation of pore-size distribution, determination of hydraulic conductivity under saturated and unsaturated conditions, determination of infiltration rate of soil, determination of aeration porosity and oxygen diffusion rate, soil temperature measurements, estimation of water balance components in bare and cropped fields.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Scope of soil physics and its relation with other branches of soil science, Soil as a three phase system	2
2.	Soil texture, textural classes, mechanical analysis, specific surface	2
3.	Soil consistence; dispersion and workability of soils	2
4.	Soil compaction and consolidation	2
5.	Soil strength; swelling and shrinkage - basic concepts	2

6.	Soil structure - genesis, types, characterization and management soil structure	2
7.	Soil aggregation, aggregate stability	1
8.	Soil tilth, characteristics of good soil tilth	1
9.	Soil crusting - mechanism, factors affecting and evaluation	1
10.	Soil conditioners and Puddling, its effect on soil physical properties and clod formation.	2
11.	Water flow in saturated soils	1
12.	Water flow in unsaturated soils	1
13.	Poiseuille's law and Darcy's law	1
14.	Hydraulic conductivity and hydraulic diffusivity	1
15.	Measurement of hydraulic conductivity in saturated and unsaturated soils.	1
16.	Permeability and fluidity	1
17.	Infiltration and Internal drainage and redistribution	1
18.	Evaporation, hydrologic cycle, field water balance	2
19.	Soil-plant-atmosphere continuum	1
20.	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
21.	Modes of energy transfer in soils	1
22.	Energy balance; thermal properties of soil	1
23.	Measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management	2

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Mechanical analysis by pipette and international methods	1
2.	Determination of bulk density of soil by core sampler method	1
3.	Measurement of Atterberg limits	1
4.	Aggregate analysis - dry and wet methods	1
5.	Measurement of soil-water content by different methods	1
6.	Measurement of soil-water potential by using tensiometer	1
7.	Measurement of soil-water potential by using gypsum blocks	1
8.	Determination of soil-moisture characteristics curve and computation of pore-size distribution	1
9.	Determination of hydraulic conductivity under saturated conditions	1
10.	Determination of hydraulic conductivity under unsaturated conditions	1
11.	Determination of infiltration rate of soil	1
12.	Determination of aeration porosity	1
13.	Determination of oxygen diffusion rate	1
14.	Soil temperature measurements	1
15.	Estimation of water balance components in bare fields	1
16.	Estimation of water balance components in e and cropped fields	1

Suggested Readings

- Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP & Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR & 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 & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

SOILS 532

Management Of Problem Soils And Waters

3(2+1)

Objective

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible, morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties, management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils, acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management, quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality, agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, determination of cations (Na^+ , K^+ , Ca^{++} and Mg^{++}) in ground water and soil, samples, determination of anions (Cl^- , SO_4^{--} , CO_3^{--} and HCO_3^-) in ground waters and soil samples, lime requirements of acid soil and gypsum requirements of sodic soil.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils	2
2.	Origin and basic concept of problematic soils, and factors responsible	3
3.	Morphological features of saline, sodic and saline-sodic soils	2
4.	Characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties	2
5.	Management of salt-affected soils	2
6.	Salt tolerance of crops - mechanism and ratings	2
7.	Monitoring of soil salinity in the field	1
8.	Management principles for sandy, clayey, red lateritic and dry land soils	3
9.	Acid soils - nature of soil acidity, sources of soil acidity	1
10.	Soil acidity effect on plant growth and lime requirement of acid soils	2
11.	Management of acid and acid sulphate soils	2
12.	Biological sickness of soils and its management	2
13.	Quality of irrigation water and their crop response	2
14.	Management of brackish water for irrigation	2
15.	Salt balance under irrigation	1
16.	Characterization of brackish waters, area and extent, relationship in water use and quality	3

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Characterization of acid and acid sulfate soils salt-affected and calcareous soils	1
2.	Characterization of salt-affected soils	1
3.	Characterization of calcareous soils	1
4.	Determination of Ca^{++} and Mg^{++} in soil	1
5.	Determination of Ca^{++} and Mg^{++} in ground water	1
6.	Determination of Potassium in ground water	1
7.	Determination of Potassium in soil	1
8.	Determination of sodium in ground water	1
9.	Determination of sodium in soil	1

10.	Determination of CO ₃ ²⁻ and HCO ₃ ⁻ in ground waters	1
11.	Determination of CO ₃ ²⁻ and HCO ₃ ⁻ in soil	1
12.	Determination of chloride in ground waters	1
13.	Determination of chloride soil	1
14.	Determination of sulphate (SO ₄ ²⁻) in ground waters	1
15.	Determination of sulphate (SO ₄ ²⁻) in soil	1
16.	Determination of gypsum requirement of sodic soil	1
17.	Determination of lime requirement of acid soil	1

Suggested Readings

Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State Univ.

USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

SOILS 611

Advances in soil fertility

3(2+1)

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices, nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils, chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils, modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting, modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture, monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Practical

Determination of Q / I relationship of P and K, determination of cations exchange capacity of roots-cereals and legume, study of mobility of nutrients and metallic cations in soil columns, incubation studies on the solubilization of rock phosphates using chemical and biological agents, determination of phosphate potential in soil.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Modern concepts of nutrient availability	1
2.	Soil solution and plant growth	1
3.	Nutrient response functions and availability indices	2
4.	Nutrient movement in soils	1
5.	Nutrient absorption by plants	1
6.	Mechanistic approach to nutrient supply and uptake by plants	1
7.	Models for transformation and movement of primary nutrients in soils.	2
8.	Models for transformation and movement of secondary nutrients in soils	2
9.	Models for transformation and movement of micronutrients in soils.	3
10.	Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils	1
11.	Chemical equilibria (including solid-solution equilibria) involving nutrient ions in submerged soils.	1
12.	Modern concepts of fertilizer evaluation	1
13.	Nutrient use efficiency	1
14.	Nutrient budgeting	1

15.	Modern concepts in fertilizer application	1
16.	Soil fertility evaluation: Define, concept and techniques	1
17.	Soil fertility evaluation : Biological methods, use of visual symptoms of nutrient deficiency or toxicity	2
18.	Soil fertility evaluation : Plant analysis method – DRIS methods, critical levels in plants, rapid tissue tests, indicator plants	1
19.	Soil fertility evaluation: Soil analysis methods – critical levels of different nutrients in soil.	1
20.	Role of soil tests in fertilizer use and recommendations	1
21.	Site-specific nutrient management for precision agriculture	2
22.	Monitoring physical, chemical and biological changes in soils	2
23.	Permanent manurial trials and long-term fertilizer experiments	2
24.	Soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use	2

Lecture schedule— Practical

S. No.	Topic	No. of lecture
1.	Determination of Q / I relationship of P and K	2
2.	Determination of cations exchange capacity of cereals roots	2
3.	Determination of cations exchange capacity of legume roots	2
4.	Study of mobility of nutrients and metallic cations in soil columns	3
5.	Incubation studies on the solubilization of rock phosphates using chemical and biological agents	5
6.	Determination of phosphate potential in soil	2

Suggested Readings

- Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.
- Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.
- Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.
- Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.
- Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.
- Kabata-Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. *Micronutrients in Agriculture*. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.
- Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers*. 5th Ed. Macmillan Publ.
- Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed. Longman.

SOILS 612

Advances in soil physics

3(3+0)

Objective

To provide knowledge of modern concepts in soil physics.

Theory

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, fundamentals of fluid flow, Poiseuille's law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional

water flow, theories of horizontal and vertical infiltration under different boundary conditions., movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves. soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil, soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in agriculture, solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Lecture schedule—Theory

S. No	Topic	No. of lecture
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.	1
3	Fundamentals of fluid flow in saturated and unsaturated flows;capillary conductivity and diffusivity	2
4	Poiseuilles law, Laplace’s equation in saturated and unsaturated flows;capillary conductivity and diffusivity	3
5	Darcy’s law in saturated and unsaturated flows;capillary conductivity and diffusivity	2
6	Limitations of Darcy’s law; numerical solution for one dimensional water flow.	2
7	Theories of horizontal under different boundary conditions.	2
9	Theories of vertical infiltration under different boundary conditions.	2
10	Movement of salts in soils,	1
11	Models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations	2
12	Break-through curves of salt movement in soil	1
13	Soil air and aeration,	2
14	Mass flow and diffusion processes of air movement	2
15	Thermal properties of soil,	2
16	Heat transfer in soils	2
17	Differential equation of heat flow in soil	2
18	Measurement of thermal conductivity of soil.	2
19	Soil crust and clod formation	2
20	Structural management of puddled rice soils;	2
21	Soil conditioners	1
22	Types and characteristics of soil conditioners	2
23	Working principles of soil conditioners	2
24	Significance of soil conditioners in agriculture.	2
25	Solar and terrestrial radiation measurement	2
26	Dissipation and distribution solar and terrestrial radiation in soil-crop systems	2
27	Prediction of evapotranspiration using aerodynamic and canopy temperature-based models;	2
28	Canopy temperature and leaf diffusion resistance in relation to plant water deficit	2
29	Evaluation of soil and plant water status using infra-red thermometer.	2

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
Hanks and Ascherof. 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 & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.
Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Objective

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

Colloidal chemistry of inorganic and organic components of soils – their formation, clay organic interaction, 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, thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction, adsorption/ desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system), common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Colloidal chemistry of inorganic components of soils – their formation clay organic interaction.	2
2.	Colloidal chemistry of organic components of soils – their formation, clay organic interaction.	2
3.	Predictive approaches for cation exchange equilibria - thermodynamics	2
4.	Empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients	3
5.	Structure and properties of diffuse double layer.	2
6.	Thermodynamics of nutrient transformations in soils	3
7.	Cationic and anionic exchange and their models, molecular interaction	3
8.	Adsorption/desorption isotherms	2
9.	Langmuir adsorption isotherm	1
10.	Freundlich adsorption isotherm	1
11.	Normalized exchange isotherm	1
12.	BET equation	1
13.	Selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system)	3
14.	Common solubility equilibria of carbonates	1
15.	Common solubility equilibria of iron oxide and hydroxides	1
16.	Common solubility equilibria of aluminum silicate	1
17.	Common solubility equilibria of aluminum phosphate	1
18.	Electrochemical properties of clays (citation of examples from agril. use).	2

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Fried M & Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition*. Academic Press.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.

Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.

McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford Univ. Press Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.

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

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools, biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids, nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils, reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes, humus - pesticide interactions in soil, mechanisms.

Practical

Determination of soil organic carbon by dry combustion, rapid titration and colorimetric methods, fractionations of soil organic matter (HA,FA,Humin,Lignin and Humus), estimation of humatmelanic,humic acid,β humus and fulvic acid, determination of CEC and functional group of humic substances, elemental composition of organic matter.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Organic matter pools in soil	2
2.	Composition and distribution of organic matter in soil and its functions	2
3.	Humic substances: structure and concept	3
4.	Environmental significance of humic substances	2
5.	Decomposition of organic residues in soil in relation to organic matter pools.	3
6.	Biochemistry of the humus formation	2
7.	Different pathways for humus synthesis in soil	3
8.	Soil carbohydrates and lipids.	2
9.	Nutrient transformation of N and interaction with humic substances	2
10.	Nutrient transformation of P and interaction with humic substances	2
11.	Nutrient transformation of S and interaction with humic substances.	2
12.	Significance of chelation reactions in soils	1
13.	Reactive functional groups of humic substances,	1
14.	Adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes	2
15.	Clay-organic matter complexes	1
16.	Humus - pesticide interactions in soil, mechanisms	2

Lecture schedule—Practical

S. No.	Topic	No. of lecture
1.	Determination of soil organic carbon by dry combustion method	1
2.	Determination of soil organic carbon by rapid titration method	1
3.	Determination of soil organic carbon by colorimetric method	1
4.	Fractionations of soil organic matter (HA,FA,Humin,Lignin and Humus)	5
5.	Estimation of humatmelanic, humic acid, β humus and fulvic acid	4
6.	Determination of CEC and functional group of humic substances	3
7.	Elemental composition of organic matter	1

Suggested Readings

Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. *Organic Substances in Soil and Water: Natural Constituents and their Influences on Contaminant Behavior*. Royal Society of Chemistry, London.

Gieseking JE. 1975. *Soil Components*. Vol. 1. *Organic Components*. Springer-Verlag.

- Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A Global Perspective*. CSIRO Publ.
- Magdoff F & Weil RR 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.
- Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture*. John Wiley & Sons.
- Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.
- Stevenson FJ. 1994. *Humus Chemistry – Genesis, Composition and Reactions*. John Wiley & Sons.

SOILS 623 Land Use Planning and Watershed Management

3(3+0)

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

Concept and techniques of land use planning; factors governing present land use, land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application, agro-ecological regions/sub-regions of India and their characteristics in relation to crop production, water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity, watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Concept of land use planning;	2
2.	Techniques of land use planning;	2
3.	Factors governing present land use.	3
4.	Land evaluation methods	3
5.	Soil-site suitability evaluation for different crops	2
6.	Land capability classification and constraints in application.	3
7.	Agro-ecological regions/sub-regions of India	2
8.	Agro-ecological regions of India and their characteristics in relation to crop production.	3
9.	Agro-ecological sub-regions of India and their characteristics in relation to crop production	3
10.	Concept of water harvesting	1
11.	Significance of water harvesting	2
12.	Types of water harvesting	2
13.	Methodology of water harvesting	2
14.	Use of harvested water in agriculture to increase water productivity.	2
15.	Concept and objectives of watershed development/management	2
16.	Characterization of watershed	1
17.	Planning, execution, community participation and evaluation of watershed	2
18.	Rehabilitation of watershed;	2
19.	Developing economically and ecologically sustainable agro-forestry systems for watershed	3

Suggested Readings

- All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.
- FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.
- Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.
- Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8th Ed. USDA & NRCS, Washington, DC.
- USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

SOILS 624

Soil genesis and micropedology

3(3+0)

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

Pedogenic evolution of soils; soil composition and characterization, weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals, assessment of soil profile development by mineralogical and chemical analysis, micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Lecture schedule—Theory

S. No	Topic	No. of lecture
1.	Pedogenic evolution of soils	2
2.	Pedogenic Processes in soil formation	2
3.	Fundamental Pedogenic Processes	3
4.	Specific Pedogenic Processes	3
5.	Weathering of soil formation	3
6.	Physical Weathering	2
7.	Chemical Weathering	2
8.	Biological Weathering	2
9.	Weathering of minerals	3
10.	Weathering sequence of minerals	2
11.	Stages of Weathering of soil minerals	2
12.	Weathering results	1
13.	Role of weathering in soil formation	2
14.	Active factors affecting soil formation	3
15.	Passive factors affecting soil formation	3
16.	Assessment of soil profile development by mineralogical analysis	2
17.	Assessment of soil profile development by chemical analysis	2
18.	Formation of primary minerals	2
19.	Formation of Secondary minerals	2
20.	Micro-pedological features of soils	1
21.	Micro-pedological features of soil structure	1
22.	Role of Micro-pedological features of soils in fabric analysis, genesis and classification.	3

Suggested Readings

Boul SW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
Brewer R. 1976. *Fabric and Mineral Analysis of Soils*. John Wiley & Sons.

List of Journals

- Advances in Agronomy
- Annals of Arid Zone
- Australian Journal of Agricultural Research
- Australian Journal of Soil Research
- Biology and Fertility of Soils
- Communications in Soil Science and Plant Analysis
- Clays and Clay minerals
- European Journal of Soil Science
- Geoderma
- Indian Journal of Agricultural Sciences
- Journal of Plant Nutrition and Soil Science
- Journal of the Indian Society of Soil Science
- Nutrient Cycling in Agroecosystems
- Plant and Soil

- Soil and Tillage Research
- Soil Biology and Biochemistry
- Soil Science
- Soil Science Society of America Journal
- Soil Use and Management
- Water, Air and Soil Pollution
- Water Resources Research

STATISTICS, MATHEMATICS AND COMPUTER SCIENCE

Semester wise distribution of courses

M.Sc. (Ag) and Ph.D.

Course Code	Course title	<i>Credits</i>
MATH 521	Mathematical Methods	3+0
STAT 511	Statistical Methods	2+1
STAT 521	Experimental Designs	2+1
STAT 522	Sampling Techniques	2+1
STAT 523	Data Analysis Using Statistical Packages	2+1
STAT 524	Applied Regression Analysis	2+1

STAT 531	Time Series Analysis	2+1
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MATH 521

Mathematical Methods

3 (3+0)

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to differentiation, integration and differential equation,

Theory:

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc, integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc., vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis, Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Lecture schedule: Theory

S. No.	Topics	No. of Lectures
1.	Variables, Functions, Evaluation of Functions, Operations with functions	3
2.	Limits, continuity, $\lim_{x \rightarrow a} \frac{x^n - a^n}{x - a}$,	2
3.	Limits $\lim_{x \rightarrow 0} \frac{\sin x}{x}$, $\lim_{n \rightarrow \infty} \left(1 + \frac{1}{n}\right)^n$	2
4.	Specific functions, Differentiation Formulae differentiation of sum and product of functions	2
5.	Quotient rule, function of functions	2
6.	Differentiation of function of functions, Parametric Equation	3
7.	Successive differentiation	1
8.	Partial derivatives	1
9.	Determination of point of inflexion	1
10.	Maxima and minima	2
11.	Integration	1
12.	Integration Formulae	1
13.	Integration by Substitution	2
14.	Integration by Parts	2
15.	Reduction Formulae	2
16.	Definite Integration	1
17.	Vectors	1
18.	Matrices, notations	1
19.	Matrix Addition, equality of matrices, square matrix, identity, null matrix	2
20.	Subtraction, Scalar Multiplication, Matrix Multiplication, Transpose of a Matrix	2
21.	Inverse of Matrix	2
22.	Eigen Values	2
23.	Eigen Vectors	2

24.	Determinants 2*2, 3*3	1
25.	Properties of determinants	2
26.	Symmetric, skew-symmetric matrix, Cramer's rule for solving system of linear equations	2
27.	Set Theory, Set operations	1
28.	Finite and infinite sets	1
29.	Function defined in terms of sets	1

References

1. Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
2. Hohn FE. 1973. *Elementary Matrix Algebra*. Macmillan.
3. Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.
4. Stewart J. 2007. *Calculus*. Thompson.
5. Thomas GB. Jr. & Finney RL. 1996. *Calculus*. 9th Ed. Pearson Edu.

STAT 511

Statistical Methods

3(2+1)

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation, Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory, Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination, Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F ; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, Nonparametric tests.

Lecture schedule: Theory

S. No.	Topics	No. of Lectures
1.	Classification, tabulation	2
2.	Exploratory data analysis	1
3.	Theory of probability	2
4.	Random variable and mathematical expectation	1
5.	Binomial, Poisson, Negative Binomial, Normal distribution	4
6.	Beta and Gamma distributions and their applications	2
7.	Tests of significance for large samples	2

8.	Tests of significance for small samples	3
9.	theory of estimation and confidence-intervals	2
10	Simple partial and multiple correlation	3
11	Simple and partial regression	3
12	Non parametric tests	1
13	One sample non parametric tests	2
14	Two sample non parametric tests	2
15	k sample non parametric tests	2

Lecture schedule: Practical

S. N.	Topics	No. of Lectures
1.	Box-Cox plots	1
2.	Fitting of Binomial distribution	1
3.	Fitting of Poisson distribution	1
4.	Fitting of Negative binomial distribution	1
5.	Fitting of Normal distribution	1
6.	Large Sample tests	1
7.	Chi Square test	1
8.	One sample, two sample and paired t test	1
9.	F- test	1
10.	Computation of Simple correlation	1
11.	Computation of partial and multiple correlation	1
12.	Computation of Simple and partial regression	1
13.	Computation of Run test	1
14.	Sign and sign wilcoxon test	1
15.	Mann-whitney U test	1
16.	Kruskal- Wallis test	1

References:

1. Anderson TW. 1958. *An Introduction to Multivariate Statistical Analysis*. John Wiley.
2. Dillon WR & Goldstein M. 1984. *Multivariate Analysis - Methods and Applications*. John Wiley.
3. Goon AM, Gupta MK & Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
4. Goon AM, Gupta MK & Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
5. Hoel PG. 1971. *Introduction to Mathematical Statistics*. John Wiley.
6. Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*. Macmillan.
7. Morrison DF. 1976. *Multivariate Statistical Methods*. McGraw Hill.
8. Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
9. Learning Statistics: <http://freestatistics.altervista.org/en/learning.php>.
10. Electronic Statistics Text Book: <http://www.statsoft.com/textbook/stathome.html>.

STAT 521

Experimental Designs

3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control, Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design, Factorial experiments, (symmetrical as well as asymmetrical), orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment, Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures. **Practical** Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Lecture schedule: Theory

S. No.	Topics	No. of Lectures
1.	Basic concepts of design of experiment	2
2.	Basic principles of designs	3
3.	Uniformity trials	1
4.	Size and shape of plots and blocks	1
5.	Analysis of variance and transformations	2
6.	CRD, RBD and LSD	3
7.	Factorial experiments	4
8.	Confounding in symmetrical factorial experiments	2
9.	Factorial experiments with control treatment	2
10.	Split plot design	2
11.	Strip plot design	2
12.	Analysis of covariance and missing plot techniques	2
13.	crossover designs	1
14.	resolvable designs	1
15.	Response surfaces	2
16.	Experiments with mixtures	2

Lecture schedule: Practical

S. N.	Topics	No. of Lectures
1.	Formation of plots	1
2.	Formation of blocks	1
3.	Analysis of CRD	1
4.	Analysis of RBD	1
5.	Analysis of LSD	1
6.	Analysis of factorial experiment	1

7.	Analysis of asymmetric factorial experiments	1
8.	Analysis of confounded factorial experiments	1
9.	Analysis with missing data in RBD	1
10.	Analysis with missing data in LSD	1
11.	Transformation of data	1
12.	Analysis of SPD	1
13.	Analysis of strip plot design	1
14.	Analysis of resolvable designs	1
15.	Fitting of response surfaces	2

References:

1. Cochran WG & Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
2. Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.
3. Federer WT. 1985. *Experimental Designs*. MacMillan.
4. Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
5. Nigam AK & Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
6. Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.
7. Design Resources Server: www.iasri.res.in/design.

STAT 522

Sampling Techniques

3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population, Simple random sampling, sampling for proportion, determination of sample size; inverse sampling, Stratified sampling, Cluster sampling, PPS sampling, Multi-stage sampling, double sampling, systematic sampling; Use of auxiliary information at estimation as well as selection stages, Ratio and regression estimators. Construction and analysis of survey designs, sampling and non-sampling errors; Preparation of questionnaire Non-sampling errors.

Practical

Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

Lecture schedule: Theory

S. No.	Topics	No. of Lectures
1.	Concept of sampling	2
2.	sample survey vs complete enumeration	2
3.	planning of sample survey	2
4.	sampling from a finite population	2

5.	Simple random sampling	3
6.	Stratified sampling	3
7.	systematic sampling	2
8.	Cluster sampling	2
9.	Multi-stage sampling	2
10.	double sampling	2
11.	PPS sampling	2
12.	Ratio and regression estimators	3
13.	sampling and non-sampling errors	3
14.	Preparation of questionnaire	2

Lecture schedule: Practical

S. No.	Topics	No. of Lectures
1.	Random sampling ~ use of random number tables	2
2.	Determination of sample size in SRS	2
3.	Estimation of mean and variance in simple and stratified sampling	3
4.	Estimation of sample size in stratified sampling	2
5.	Cluster sampling	1
6.	Systematic sampling	1
7.	Ratio and regression estimator	1
8.	Multi stage sampling	2
9.	Double sampling	1
10.	PPS sampling	1

References:

1. Cochran WG. 1977. *Sampling Techniques*. John Wiley.
2. Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
3. Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
4. Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

STAT 523

Data Analysis Using Statistical Packages

3(2+1)

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students an hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis, Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics, Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs, Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression, Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pair wise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis-obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Lecture schedule: Theory

S. No.	Topics	No of Lectures
1.	Uses of software packages	2
2.	Summarization and tabulation of data	2
3.	Descriptive statistics	2
4.	Graphical representation of data	2
5.	large sample test	2
6.	Small Sample test	2
7.	Analysis of Variance	2
8.	Analysis of Covariance	2
9.	Estimation of variance components	2
10.	Testing the significance of contrasts	2
11.	Correlation and regression	2
12.	Factor analysis	2
13.	Principal component analysis	2
14.	Analysis of time series data	2
15.	Fitting of non-linear models	2
16.	Spatial analysis	2

Lecture schedule: Practical

S. N.	Topics	No. of Lectures
1.	Obtaining descriptive statistics	1
2.	graphical representation of data	1
3.	Fitting and testing the goodness of fit of probability distributions	2

4.	large sample test	2
5.	Small Sample test	2
6.	principal component analysis	1
7.	Analysis of time series data	1
8.	fitting of ARIMA models	1
9.	Spatial analysis	1

References:

1. Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.
2. Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.
3. Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmont, California.
4. Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis*. Chapman & Hall.
5. Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.
6. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
7. Cleveland WS. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
8. Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
9. Erickson BH & Nosanchuk TA. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
10. Snell EJ & Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman & Hall.
11. Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
12. Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
13. Velleman PF & Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
14. Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
15. Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
16. Wetherill GB. 1986. *Regression Analysis with Applications*. Chapman & Hall.

STAT 524

Applied Regression Analysis

3(2+1)

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing, Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions, Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification, Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in

outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Lecture scheduel: Theory

S. No.	Topics	No. of Lectures
1.	Components of a time-series	4
2.	Autocorrelation and Partial autocorrelation functions	4
3.	Autoregressive	4
4.	Linear non-stationary models	4
5.	Forecasting and updating forecasts	6
6.	Model identification and Model estimation	4
7.	Seasonal models	2
8.	Intervention analysis models and Outlier detection	4

Lecture schedule: Practical

S. No.	Topics	No. of lectures
1.	Time series analysis	2
2.	autocorrelations	2
3.	correlogram and periodogram	2
4.	Linear stationary model	2
5.	Linear non-stationary model	2
6.	Partial regression coefficients	2
7.	Model identification and model estimation	2
8.	Intervention analysis and outliers detection	2

References:

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

STAT 531

Time Series Analysis

3(2+1)

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis, Linear stationary models: Autoregressive, Moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes, Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts, Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection.

Lecture Schedule: Theory

S. No.	Topics	No. of Lectures
1.	Correlation analysis and Correlation from grouped data	3
2.	Biserial correlation and Rank correlation	2
3.	Multiple and partial correlation coefficients	3
4.	Testing of population correlation coefficients	1
5.	Auto correlation and its removal	3
6.	multiple regression equation	2
7.	methods of selecting the best regression equation	2
8.	regression approach applied to analysis of variance	2
9.	Heteroscedastic models	4
10.	fitting of curves	4
11.	Orthogonal polynomial	6

Lecture Schedule: Practical

S. No.	Topics	No. of Lectures
1.	Measure of Correlation coefficient	1
2.	Measure of partial and multiple correlation coefficients	3
3.	Testing of correlation coefficients	1
4.	Multiple Linear regression analysis	3
5.	Partial regression coefficients	1
6.	Outlier detection	2
7.	Fitting of quadratic curves	1
8.	Fitting of exponential and power curves	2
9.	fitting of orthogonal polynomials	2

References:

1. Box GEP, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.
2. Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
3. Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples*. John Wiley.
4. Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
5. Johnston J. 1984. *Econometric Methods*. McGraw Hill.
6. Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
7. Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.
8. Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples*. 2nd Ed. Springer.