ನೇಗಿಲ ಮೇಲೆಯೇ ನಿಂತಿದೆ ಧರ್ಮ

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Keladi Shivappa Nayaka
University of Agricultural and Horticultural Sciences
Shivamogga

MAJOR COURSE SYLLABI FOR
PH.D. DEGREE PROGRAMMES IN AGRICULTURE AND FORESTRY

Revised Syllabi as per BSMA

2022-2023

DIRECTORATE OF POST GRADUTE STUDIES

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KELADI SHIVAPPA NAYAKA

UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES,

SHIVAMOGGA

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CONTENTS

Ph.D. in Agriculture

AGRONOMY

Course Title with Credit Load

Ph.D. in Agronomy

Course Code	Course Title	Credit Hours
Agron 601*	Current trends in Agronomy	3(3+0)
Agron 602	Recent trends in crop growth and productivity	3(2+1)
Agron 603	Irrigation management	3(2+1)
Agron 604	Recent trends in weed management	2(2+0)
Agron 605	Integrated farming systems for sustainable Agriculture	2(2+0)
Agron 606	Soil Conservation and Watershed Management	3(2+1)
Agron 607	Stress Crop Production	3(2+1)
Agron 608*	Research and Publication ethics	2(2+0)

*Core Courses for Doctoral Programme

Course Contents
Ph.D. in Agronomy

I. Course Title : Current Trends in Agronomy

II. Course Code : Agron 601

III. Credit Hours : 3(3+0)

IV. Aim of the course

To acquaint the students about recent advances in agricultural production.

V. Theory

Unit I

Agro-physiological basis of variation in yield, recent advances in soilplant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant management Mechanizationin crop production: modern agricultural precision tools and technilogies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Recent advances in agricultural production

VIII. Suggested Reading

- Agarwal RL. 1995. Seed Technology. Oxford & IBH.
- Dahiya BS and Rai KN. 1997. Seed Technology. Kalyani.
- Govardhan V. 2000. Remote Sensing and Water Management in Command Areas: Agroecological Prospectives. IBDC.
- ICAR. 2006. Hand Book of Agriculture. ICAR.

- Narasaiah ML. 2004. World Trade Organization and Agriculture. Sonali Publ.
- Palaniappan SP and Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.
- Sen S and Ghosh N. 1999. Seed Science and Technology. Kalyani.
- Tarafdar JC, Tripathi KP and Kumar M. 2007. Organic Agriculture Scientific Publ.
- Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. A Text Book of Seed Technology. Kalyani Publication.
- Reddy SR and Prabhakara G. 2015. Dryland Agriculture. Kalyani Publishers.
- Gururajan B, Balasubhramanian R and Swaminath V. 2013. Recent Strategies on Crop Produc tion. Kalyani Publishers.
- Venkateswarlu B and Shanker Arun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian Journal of Agronomy 54(2): 226-230.

I. Course Title : Recent Trends in Crop Growth and Productivity

II. Course Code : Agron 602

III. Credit Hours : 3(2+1)

IV. Aim of the course

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

V. Theory

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

VI. Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., atdifferent stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc in inter cropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VIII. Learning outcome

Experience on the knowledge of crop growth for agricultural production

IX. Suggested Reading

- Chopra VL and Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Re sistance in Crop Plants. Oxford & IBH.
- Delvin RM and Vitham FH. 1986. Plant Physiology. CBS Publ.
- Evans LT. 1975. Crop Physiology. Cambridge Univ. Press.
- Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.
- Gupta US. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.
- Gupta US. 1988. Progress in Crop Physiology. Oxford & IBH.
- Kramer PJ and Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.
- Mukherjee S and Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. Plant Physiology: Research Methods. Scientific Pub.
- Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

I. Course Title : Irrigation Management

II. Course Code : Agron 603

III. Credit Hours : 3(2+1)

IV. Aim of the course

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

V. Theory

Unit I

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit VIII

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit IX

Economic analysis of irrigation and cop planning for optimum use of irrigation water

Unit X

Crop water production function

VI. Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination Moisture extraction pattern of crops
- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop efficient of one important crop
- Planning, designing and installation of drip irrigation system
- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies
- Determination of irrigation timing under different methods of irrigation
- Visit to irrigation command area

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VIII. Learning outcome

Management of irrigation water for sustainable agriculture

IX. Suggested Reading

- MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
- FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Mishra RR and Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH

I. Course Title : Recent Trends in Weed Management

II. Course Code : Agron 604

III. Credit Hours : 2(2+0)

IV. Aim of the course

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

V. Theory

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

VIII. Suggested Reading

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.
- Das TK. 2008. Weed Science: Basics and Applications, Jain Brothers (New Delhi)
- Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. Weed Management: Principles and Practices, 2nd Ed.
- Jugulan M, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. Weed Science Principles and Practices, Wiley
- Powles SB and Shaner DL. 2001. Herbicide Resistance and World Grains, CRC Press.
- Walia US. 2006. Weed Management, Kalyani.
- Zimdahl RL. (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub

I. Course Title : Integrated Farming Systems and Sustainable Agriculture

II. Course Code : Agron 605

III. Credit Hours : 2(2+0)

IV. Aim of the course

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

V. Theory

Unit I

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

Unit II

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management.

Unit III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

Unit IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

Unit V

New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of enterprises suitable for different agroclimatic conditions for sustainable agriculture and their proper utilization .

VIII. Suggested Reading

- Ananthakrishnan TN. (Ed.). 1992. Emerging Trends in Biological Control of Phytophagous In sects. Oxford & IBH.

- Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience. Omni Scriptum Gmbh & Co. KG, Germany.
- Balasubramanian P and Palaniappan SP. 2006. Principles and Practices of Agronomy. Agrobios.
- Edens T. 1984. Sustainable agriculture and integrated farming system. Michigan State Univ. press.
- Jayanthi C. 2006. Integrated Farming systems-A way to sustainable Agriculture. Tamil Nadu Agricultural University, Coimbatore
- Joshi M and Parbhakarasetty TK. 2005. Sustainability through Organic Farming. Kalyani.
- Kolhapure A and Madhukar D. A text book of farming system and sustainable agriculture.
- Palaniappan SP and Anandurai K. 1999. Organic Farming - Theory and Practice. Scientific Publ.
- Panda SC. 2004. Cropping systems and Farming Systems. Agribios.
- Lampin N. 1990. Organic Farming. Farming Press Books.
- Ravisankar D and Jayanthi C. 2015. Farming systems: concepts and approaches. Agrobios,

I. Course Title : Soil Conservation and Watershed Management

II. Course Code : Agron 606

III. Credit Hours : 3(2+1)

IV. Aim of the course

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

V. Theory

Unit I

Soil erosion: definition, nature and affecting erosion; types of erosion, factors affecting erosion.

Unit II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

Unit III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

Unit IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

Unit V

Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

VI. Practical

- Study of different types of erosion
- Determination of dispersion ratio
- Estimation of soil loss by Universal Soil Loss Equation
- Estimation of soil loss by wind erosion
- Measurement of runoff and soil loss
- Field studies of different soil conservation measures
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to watershed areas
- Visit to a soil conservation research centre, demonstration and training centre

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VIII. Learning outcome

Experience on the knowledge of soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

IX. Suggested Reading

- Arakeri HR and Roy D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
- Dhruvanarayana VV. 1993. Soil and Water Conservation Research in India. ICAR.
- FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.
- Frederick RT, Hobbs J, Arthur D and Roy L. 1999. Soil and Water Conservation: Productivity and Environment Protection. 3rd Ed. Prentice Hall.
- Gurmel Singh, Venkataraman CG, Sastry B and Joshi P. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
- Murthy VVN. 1995. Land and Water Management Engineering. Kalyani.
- Tripathi RP and Singh HP. 1993. Soil Erosion and Conservation. Wiley Eastern.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. Principles of Agronomy. Kalyani.

I. Course Title : Stress Crop Production

II. Course Code : Agron 607

III. Credit Hours : 3(2+1)

IV. Aim of the course

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

V. Theory

Unit I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

Unit II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

Unit III

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

Unit IV

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

Unit V

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

Unit VI

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Unit VII

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

Unit VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

VI. 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
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of various types of stresses in cropproduction and strategies to overcome these.

VIII. Suggested Reading

- Baker FWG.1989. Drought Resistance in Cereals. Oxon, UK.
- Gupta US. (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.1978. Introduction to Agro-meteorology. Oxford & IBH.
- Michael AM and Ojha TP.1981. Principles of Agricultural Engineering. Vol II. Jain Bros.
- Nilsen ET and Orcut DM. 1996. Physiology of Plants under Stress – Abiotic Factors. John Wiley & Sons.
- Singh K. 2000. Plant Productivity under Environmental Stress. Agribios.
- Singh KN and Singh RP. 1990. Agronomic Research Towards Sustainable Agriculture. Indian Society of Agronomy, New Delhi.
- Somani LL and Totawat KL. 1992. Management of Salt-affected Soils and Waters. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. Stressed Ecosystem and Sustainable Agriculture. Oxford & IBH.

I. Title : Research and Publication Ethics

II. Course Code : Agron 608

III. Credit Hours : 2(0+2)

IV. Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to checkpublisher copy right and selfarchivingpolicies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggesteretc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open sourcesoftware tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-indexaltmetrics.

V. Teaching methods/activities

Classroom teaching with AV aids, group discussion, field practicals and laboratory visit.

VI. Learning outcome

Developed skill for research management, quality publication.

ENTOMOLOGY

Course Title with Credit Load
Ph.D. in Plant Protection-Entomology

Course Code	Course Title	Credit Hours
ENT 601**	Insect Phylogeny and Systematics	3(1+2)
ENT 602**	Insect Physiology and Nutrition	3(2+1)
ENT 603**	Insect Ecology and Diversity	3(2+1)
ENT 604	Insect Behaviour	2(1+1)
ENT 605**	Bio-inputs for Pest Management	3(2+1)
ENT 606**	Insect Toxicology and Residues	3(2+1)
ENT 607	Plant Resistance to Insects	2(1+1)
ENT 608	Acarology	2(1+1)
ENT 609	Molecular Entomology	2(1+1)
ENT 610	Integrated Pest Management	2(2+0)

**Core Courses for Doctoral Programme

Course Contents
Ph.D. in Plant Protection-Entomology

I. Course Title : Insect Phylogeny and Systematics
II. Course Code : ENT 601
III. Credit Hours : 3 (1+2)
IV. Aim of the course

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. Detailed study about the International Code of Zoological Nomenclature; ethics and procedure for taxonomic publications.

V. Theory

Unit I

Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

Unit II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

Unit III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures.

Unit IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular sytematics.

VI. Practical

- Collection, curation and study of one taxon of insects- literature search, compilation of a check list, study of characters, development of character table, and construction of taxonomic keys for the selected group;
- Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation, Submission of the collections made of the group;
- Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms;
- Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

VII. Learning outcome

- Scholars are expected to understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity; prepare taxonomic keys for specific groups and write taxonomic papers and reviews.
- Scholars should be able to identify insects of economic importance up to family/ generic levels and specialize in any one group of insects up to species level identification.

VIII. Suggested Reading

- CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- Dakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied En tomology. Springer-Verlag, Berlin.
- Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA.
- Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
- Mayr E and Ashlock PD. 1991. Principles of Systematic Zoology. 2nd Ed. McGraw Hill, New York.
- Mayr E.1969. Principles of Systematic Zoology. McGraw-Hill, New York.
- Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London.
- Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London.
- Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.

I. Course Title : Insect Physiology and Nutrition

II. Course Code : ENT 602

III. Credit Hours : 3 (2+1)

IV. Aim of the course

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

V. Theory

Unit I

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.

Unit II

Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

Unit III

Detailed physiology of nervous system, transmission of nerve impulses, neuro- transmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

Unit IV

Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

VI. Practical

- Preparation of synthetic diets for different groups of insects;
- Rearing of insects on synthetic, semi-synthetic and natural diets;
- Determination of co-efficient of utilization;
- Qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph;
- Zymogram analyses of amylase;
- Determination of chitin in insect cuticle;
- Examination and count of insect haemocytes.

VII. Learning outcome

- The scholars are expected to have thorough theoretical and practical knowledge of insect physi ology that can be made use of in practical/ applied entomological aspects.
- Understand how physiological systems in insects are integrated to maintain homeostasis.

VIII. Suggested Reading

- Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
- Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.
- Kerkut GA and Gilbert LI. 1985. Insect Physiology, Biochemistry and Pharmacology. Vols. I-XIII Pergamon Press, Oxford, New York.
- Muraleedharan K. 1997. Recent Advances in Insect Endocrinology. Association for Advance ment of Entomology, Trivandrum, Kerala.
- Rockstein, M. 1978. Biochemistry of Insects, Academic Press.
- Simpson, SJ. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.

I. Course Title : Insect Ecology and Diversity

II. Course Code : ENT 603

III. Credit Hours : 3 (2+1)

IV. Aim of the course

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

V. Theory

Unit I

Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

Unit II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. Host seeking behavior of parasitoids.

Unit III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

Unit IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

VI. Practical

- Methods of data collection under field conditions;
- Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc.;
- Calculation of sample sizes by different methods;
- Fitting Poisson and Negative Binomial distributions and working out the data transformation methods;

- Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection, Demonstration of genetic drift;
- Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/ Goniozus/ Female Bruchids, etc.;
- A test of reproductive effort and fitness;
- Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution;
- Exercises in development of Algorithms for crop modeling;

VII. Learning outcome

- The scholar is expected to develop expertise in methods of data collection for insect population studies, data transformation for analyses, diversity estimates, assessing distribution parameters, study the impact of abiotic and biotic factors on the distribution and abundance of insects.
- Should gain significant knowledge on construction of life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

VIII. Suggested Reading

- Barbosa P and Letourneau DK. (Eds.). 1988. Novel Aspects of Insect-Plant Interactions. Wiley, London.
- Elizabeth BA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, New York.
- Freeman S and Herron JC.1998. Evolutionary Analysis. Prentice Hall, New Delhi.

  Gotelli NJ and Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Sunderland, MA.
- Gotelli NJ. 2001. A Primer of Ecology. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
- Krebs C. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001 Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed.
- Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton.
- Real LA and Brown JH. (Eds.). 1991. Foundations of Ecology: Classic Papers with Commen taries. University of Chicago Press, USA.
- Southwood TRE and Henderson PA. 2000. Ecological Methods. 3rd Ed. Wiley Blackwell, London.
- Strong DR, Lawton JH and Southwood R. 1984. Insects on Plants: Community Patterns and Mechanism. Harward University Press, Harward.
- Wratten SD and Fry GLA. 1980. Field and Laboratory Exercises in Ecology. Arnold Publ., London.

I. Course Title : Insect Behaviour

II. Course Code : ENT 604

III. Credit Hours : 2 (1+1)

IV. Aim of the course

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behavior in insects.

V. Theory

Unit I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behavior, inducted behavior, learnt behavior and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behavior- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behavior and behavioural polymorphism.

Unit II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

Unit III

Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior- kin selection, parental manipulation and mutualism; Self organization and insect behavior.

Unit IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio- chemicals, auditory stimuli and visual signals in pest management.

VI. Practical

- Quantitative methods in sampling behavior;
- Training bees to artificial feeders;
- Sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees;
- Evaluation of different types of traps against fruit flies with respect to signals;
- Use of honey bees/ Helicoverpa armigera to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

VII. Learning outcome

- Scholars are expected to be well versed with the behavior and orientation of insects towards exploitation as a tool in IPM.

VIII. Suggested Reading

- Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
- Awasthi VB. 2001. Principles of Insect Behaviour. Scientific Publ., Jodhpur.
- Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.
- Brown LB. 1999. The Experimental Analysis of Insect Behaviour. Springer, Berlin.
- Krebs JR and Davies NB. 1993. An Introduction to Behavioural Ecology. 3rd Ed. Chapman and Hall, London.
- Manning A and Dawkins MS. 1992. An Introduction to Animal Behaviour. Cambridge University Press, USA.
- Mathews RW and Mathews JR. 1978. Insect Behaviour. A Wiley-InterScience Publ. John Wiley and Sons, New York.

I. Course Title : Bio-inputs for Pest Management

II. Course Code : ENT 605

III. Credit Hours : 3 (2+1)

IV. Aim of the course

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

V. Theory

Unit I

Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents *vis-à-vis* target pest populations.

Unit II

Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio- agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

Unit III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.

Unit IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal

traits in bio-control agents for introgressing and for progeny selections, breeding techniques of bio-control agents.

VI. Practical

- Mass rearing and release of some commonly occurring indigenous natural enemies;
- Assessment of role of natural enemies in reducing pest populations;
- Testing side effects of pesticides on natural enemies;
- Effect of semio-chemicals on natural enemies, breeding of various bio-control agents, perfor mance of efficiency analyses on target pests;
- Project document preparation for establishing a viable mass-production unit/ insectary;
- Observation of feeding behavior acts of predatory bugs/ beetles.

VII. Learning outcome

- Scholars are expected to learn the mass multiplication techniques of the more common and economically feasible natural enemies to be exploited under IPM programmes.
- They should be able to guide entrepreneurs for establishing a viable mass- production unit/ insectary.

VIII. Suggested Reading

- Burges HD and Hussey NW. (Eds.). 1971. Microbial Control of Insects and Mites. Academic Press, London.
- Coppel HC and James WM. 1977. Biological Insect Pest Suppression. Springer Verlag, Berlin. De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, London. Dhaliwal, GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publishers, New Delhi.
- Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman and Hall, New York.
- Huffakar CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.

I. Course Title : Insecticide Toxicology and Residues

II. Course Code : ENT 606

III. Credit Hours : 3 (2+1)

IV. Aim of the course

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

V. Theory

Unit I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

Unit II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

Unit III

Joint action of insecticides; activation, synergism and potentiation.

Unit IV

Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

Unit V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.

VI. Practical

- Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods;
- Calculations and interpretation of data;
- Biochemical and biological techniques for detection of insecticide resistance in insects;
- Preparation of EC formulation using neem oil.

VII. Learning outcome

- Scholars are expected to be well versed with the latest technologies of bioassays, insecticide/ pesticide residue analysis and solving problems associated with insect resistance to insecticides.

VIII. Suggested Reading

- Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London. Dhaliwal GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publishers, New Delhi.
- Hayes WJ and Laws ER. 1991. Handbook of Pesticide Toxicology. Academic Press, New York.
- Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
- O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York.
- Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment.Narosa Publ. House, New Delhi.
- Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.

I. Course Title : Plant Resistance to Insects

II. Course Code : ENT 607

III. Credit Hours : 2 (1+1)

IV. Aim of the course

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

V. Theory

Unit I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species – gene pool; insect sources – behaviour in relation to host plant factors.

Unit II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

Unit III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker- aided selection in resistance breeding.

Unit IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

VI. Practical

- Understanding mechanisms of resistance for orientation, feeding, oviposition, etc., allelochemical bases of insect resistance;
- Macroculturing of test insects like aphids, leaf/ plant hoppers, mites and stored grain pests;
- Field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries;
- Determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

VII. Learning outcome

- Scholars are expected to identify sources of resistance in different crops and varieties; their utilization in resistance breeding programmes involving screening techniques for specific pests.

VIII. Suggested Reading

- Panda N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum and Co., New York.
- Rosenthal GA and Janzen DH. (Eds.). 1979. Herbivores – their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.

- Sadasivam S and Thayumanavan B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.
- Smith CM, Khan ZR and Pathak MD. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

I. Course Title : Acarology

II. Course Code : ENT 608

III. Credit Hours : 2 (1+1)

IV. Aim of the course

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

V. Theory

Unit I

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

Unit II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

Unit III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

Unit IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.

VI. Practical

- Identification of commonly occurring mites up to species, preparation of keys for identification;
- Collection of specific groups of mites and preparing their identification keys;
- Rearing phytoseiid mites and studying their role in suppression of spider mites;
- Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens, etc.

VII. Learning outcome

- Scholars should be able to identify major mite pests, their management and predatory mites that can be used in biological control.
- They are also expected to learn the rearing techniques of predatory Phytoseiid mites.

VIII. Suggested Reading

- Evans GO.1992. Principles of Acarology. CABI, London.
- Gerson H and Smiley RL. 1990. Acarine Bio-control Agents- An Illustrated Key and Manual. Chapman and Hall, New York.
- Gupta SK. 1985. Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
- Krantz GW. 1970. A Manual of Acarology. Oregon State University Book Stores, Corvallis, Oregon.
- Sadana GL. 1997. False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.

I. Course Title : Molecular Entomology

II. Course Code : ENT 609

III. Credit Hours : 2 (1+1)

IV. Aim of the course

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, and biotechnological advances in sericulture and apiculture.

V. Theory

Unit I

Introduction to molecular biology; techniques used in molecular biology.

Unit II

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.

Unit III

Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.

Unit IV

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.

Unit V

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.

VI. Practical

- Isolation of DNA/ RNA;
- Purity determinations, purification of total DNA from animal tissues;

- Base pair estimation;
- Agarose gel electrophoresis;
- Quantitative enzyme profile of alimentary canal;
- Restriction mapping of DNA;
- Demonstration of PCR, RFLP and RAPD techniques.

VII. Learning outcome

- The scholars are expected to have mastered the molecular techniques applicable in entomologi cal research like isolation of insect DNA, purification, DNA barcoding and utilizing these tech niques in molecular systematics and biological control aspects.

VIII. Suggested Reading

- Bhattacharya TK, Kumar P and Sharma A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.
- Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. Molecular Insect Science. Plenum Press, New York.
- Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
- Oakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied En tomology. Springer Verlag.
- Rechcigl JE and Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
- Roy U and SaXena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.
- Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi.
- Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

I. Course Title : Integrated Pest Management

II. Course Code : ENT 610

III. Credit Hours : 2 (2+0)

IV. Aim of the course

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

V. Theory

Unit I

Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.

Unit II

Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

Unit III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

Unit IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

VI. Learning outcome

- Having gained sufficient experience in advanced studies of IPM the scholars should be able to independently frame IPM schedules for major crops/ cropping ecosystems (cereal/ pulse crop/ oilseed crop based/ vegetable crop based agro-ecosystems).

VII. Suggested Reading

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

GENETICS AND PLANT BREEDING

Course Title with Credit Load
Ph.D. in Genetics and Plant Breeding (GPB)

Course Code	Course Title	Credit Hours
GPB 601*	Advances in Plant Breeding Systems	3(3+0)
GPB 602	Advances in Biometrical Genetics	3(2+1)
GPB 603	Molecular Cytogenetics for Crop Improvement	2(2+0)
GPB 604	Plant Genetic Resources, Conservation and Utilization	2(2+0)
GPB 605*	Genomics in Plant Breeding	3(3+0)
GPB 606	Population Genetics	2(2+0)
GPB 607	Crop Evolution	3(3+0)
GPB608	Breeding Designer Crops	2 (1+1)
GPB 609*	IPR and Regulatory Mechanisms	1(1+0)

*Core Courses for Doctoral Programme

Course Contents
Ph.D. in Genetics and Plant Breeding (GPB)

I. Course Title : Advances in Plant Breeding Systems*

II. Course Code : GPB601

III. Credit Hours : 3(3+0)

IV. Why this course?

This course is an advancement of principles, various plant breeding methodologies and procedures in the development of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker-based utilization ofexotic Germplasm and introgression libraries.

V. Aim of the course

To impart the oretical knowledge about advance sinplant breeding.

VI. Theory

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formationand various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthes is and bottle necks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding method sinsel fand cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and the irmodifications; Convergent selection, diver gent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection inclonally propagated crops–Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, finger printing and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocyto plasmicinter actions with special referenc eto male sterility–genetic, bio chemical and molecular bases.

Unit IV

Genetic engineering technologies to create male sterility, prospects and problems,use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies;Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental in fluenceon sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influenceon their expression, genetic studies;Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility andits use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencingin congruity Methods to overcome in congruity mechanisms.

Unit VII

Breeding for climate change-Improving root systems, a bioticstress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, green house gases and carbon sequestration; Breeding for bio-fortification.

VII. Teaching methods

- Power point presentation
- Chalkand Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning outcome

After completion of this course the student will be able to know various plant breeding method olo gies, principles and procedures for the formation of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker based utilization of exotic Germplasm and Breeding for climate change

IX. Suggested Reading

- AgarwalRL.1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH.
- Allard RW.1966. Principles of Plant Breeding. John Wiley & Sons.
  Briggs FN and KnowlesPF.1967.Introduction to Plant Breeding. Reinhold.
- Fehr WR.1987. Principles of Cultivar Development:Theory and Technique. VolI. Macmillan.
  Hayes HK, I mmer FR and Smith DC.1955.Methods of Plant Breeding. Mc Graw-Hill.
- Kang MS and Priyadarshan PM (Edit.).2007. Breeding Major Food Staples. Blackwell Publishing.
- KoleC.2013.Genomics and Breeding for Climate-Resilient Crops. Springer.Volume 2-Target Traits.
- MandalAK,Ganguli PK and Banerji SP.1995. Advances in Plant Breeding. Vol.I, II.CBS.
- Richards AJ.1986. Plant Breeding Systems. George Allen & Unwin.
- Sharma JR.1994. Principles and Practice of Plant Breeding. Tata Mc Graw- Hill.
- Simmonds NW. 1979. Principles of Crop Improvement. Longman.
- Singh BD.1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani Publishers, NewDelhi.
- SinghP. 1996. Essentials of Plant Breeding. Kalyani Publishers, New Delhi.
- Welsh JR.1981. Fundamentals of Plant Genetic and Breeding. John Wiley.

I. Course Title : Advances in Biometrical Genetics

II. Course Code : GPB602

III. Credit Hours : 3(2+1)

IV. Why this course?

This course is essential to understand various qualitative, quantitative systems/techniques related to genetic improvement of crops, Gx E Interaction, Construction of saturated link a gemaps and Marker Assisted Selection (MAS).

V. Aim of the course

To impart the or etical knowledge and computation methods for non-all elic interactions, mating designs and component analysis and their significance in plant breeding.

VI. Theory

Unit I

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F_2, F and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types off a milies in coupling and dispersed phase; Epistasis-Specification, weighted and un-weighted joints caling test; Effect of link a getogeneration mean, specification of mean to Gx E interaction.

Unit III

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III,Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

Unit IV

GX E Interaction, stability and adaptability; Advanced models in stability analysis -Pattern analysis-Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model-Biplots and mapping geno types.

Unit V

Construction of saturated linkage maps, concept of framework map development;QTLs-different types of markers and mapping populations, linkage maps, mapping-Strategies for QTL mapping desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding-selection based on markers-simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

VII. Practical

- Generation mean analysis: ABC scaling test and Joint scaling test-Analysis and inter pretation;
- Estimation of variance of different filial generations and interpretations;
- Diallel analysis: Numerical, graphical and combining ability analysis; Triallel analysis;
- NC Designs: Triple test cross analysis;
- Stability analysis: Eberhart and Russel model;
- AMMI model-Principal Component Analysis model-Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model-Selection systems-Biplots and mapping genotypes;
- Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping;
- Phenotype and Marker link agestudies;
- Use of advanced software in biometrical analysis.

VIII. Teaching methods

- Powerpoint presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Grouptasks, student's presentations

IX. Learning outcome

After the completion of this course student will be able to underst and various Qualitative and quantitative techniques, Gx E Interaction, Construction of saturated linkage maps and Marker Assisted Selection, Use of advanced software packages for biometrical analysis, interpretation of analysed data.

X. Suggested Reading

- BosI and Caligari P.1995. Selection Method sin Plant Breeding. Chapman & Hall.
- DabholkarAR.1993. Elements of Biometrical Genetics. Concept Publishing Co. New Delhi.
- Falconer DS and Mackay J. 1996.Introduction to Quantitative Genetics (4Ed.).ELBS /Longman, London.
- Mather Kand JinksJL.1985. Biometrical Genetics (3rdEd.).Chapmanand Hall, London.
- Nandarajan Nand Gunasekaran M.2008. Quantitative Genetics and Biometrical Techniquesin Plant Breeding. Kalyani Publishers, NewDelhi.
- Roy D.2000. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.
- Singh Pand Narayanan SS.1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
- Singh RK and Choudhary BD. 1987. Biometrical Methodsin Quantitative Genetics. Kalyani Publishers, New Delhi.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
- Wricke Gand Weber WE.1986.Quantitative Genetics and Selection in Plant Breeding.Walterde Gruyter.

I. Course Title : Molecular Cytogenetics for Crop Improvement

II. Course Code : GPB603

III. Credit Hours : 2(2+0)

IV. Why this course?

This course is needed to underst and organization and structure of genome, karyotyping, Pre-breeding and applications of cytogenetically methods for crop improvement

V. Aim of the course

This course focuses on applications of cytogenetic techniques for crop improvement.

VI. Theory

Unit I

Organization and structure of genome, Genome size, Organization of organellargenomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA;Variation in DNA content - C value paradox; Sequence complexity – Introns and Exons, Repetitive sequences, Role of repetitive sequence.

Unit II

Karyotyping–Chromosome banding and chromo some painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments.

Unit III

Pre-breeding and applications of cy to genetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Inter change genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multipleinter changes-use in producing in breds, transfer of genes-linked marker methods; Duplication-production and use; Inversions and location of genes; B/ A chromosome translocations and gene location.

Unit IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production,breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

Unit V

Cytogenomics : Concept, tools and techniques for crop improvement; Chromo some sorting: Isolation of specific chromo some for development of molecular maps and genelocation.

Unit VI

Role of polyploidy in crop evolution and breeding. Auto- and allopolyploids; Distanthy bridization, barriers to inter specific and inter generichy bridization; Behaviour of inter specific and intergeneric crosses.

VII. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board

- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning Outcome

After the completion of this course the student will be able to underst and Organization and structure of genome, karyotyping, Pre-breeding, polyploidy and applications of cy to genetically methods for crop improvement.

IX. Suggested Reading

- Clark MS and WallWJ.1996.Chromosomes: The Complex Code. Chapman & Hall.30June1996
- Conger BV. (Ed.).1981.Cloning Agricultural Plants viain-vitro Techniques. CRC Press. 31 January 2018
- Constabel Fand VasilIK. (Eds.).1988. Cell Culture and Somatic Cell Genetic sof Plants.Vol.V.
- Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
- Gupta PK. 2006. Cytogenetics. Rastogi Publisher
- LalR and LalS. (Eds.). 1990. Crop Improvement Utilizing Biotechnology. CRC Press.
- MantelS Hand Smith H.1983. Plant Biotechnology. Cambridge University Press.
- Sen S Kand Giles KL.(Eds.).1983.Plant Cell Culturein CropImprovement. Plenum Press.13July2013
- Yao- Shan F.2002. Molecular Cytogenetics: Protocols and Application. Human Press

I. Course Title : Plant Genetic Resources, Conservation and Utilization

II. Course Code : GPB604

III. Credit Hours : 2(2+0)

IV. Why this course?

This course is needed to make the student aware a bout the importance of Plant Genetic Resources its Conservation and Utilizationin crop improvement.

V. Aim of the course

To impart knowledge on the methods of germplasm conservation and itsutilization

VI. Theory

Unit I

Concept of natural reserves and natural gene banks; *Insitu* conservation of wild species in nature reserves: *insitu* conservation components, factors in fluencing conservation value, national plan for *insitu* conservation; *insitu* conservation of agro- biodiversity on-farm; scientific basis of *insitu* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *insitu* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

Unit II

Exsitu conservation: components, plant genetic resources conservation in gene banks,national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/working collections, orthodox, recalcitrant seeds-differences in handling, clonal repositories, genetic stability under long term storage condition.

Unit III

In-vitro storage, maintenance of in-vitro culture under different conditions, *in-vitro* bank maintenance for temperate and tropical fruit cropspecies, spices, tubers, bulbous crops, medicinal and endangered plants pecies, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of in-vitrogene bank.

Unit IV

Cryopreservation - procedure for handling seeds of orthodox and recalcitrant-cryo-protectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

Unit V

Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and minicore; collections and registration of plant germplasm.

VII. Teaching methods

- Power point presentation
- Chalkand Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning outcome

After the completion of this course the student will be able to know about the various techniques of conservation of Plant Genetic Resources and its Utilization in crop improvement.

IX. Suggested Reading

- Ellis RH, Roberts EH and White Head J.1980. A New More Economic and Accurate Approachto
- Monitor the Viability of Accessions During Storage in Seed Banks. FAO/ IBPGR Pl.Genet. Resources News41-3-18.
- Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cam bridge University Press, Cambridge.
- Paroda RS and Arora RK.1991.Plant Genetic resource Conservation and management, NBPGR, New-Delhi.
- Simmonds NW. 1979. Principles of Crop Improvement, Longman.
- West wood MN. 1986. Operation Manual for National Clonal Germplasm Repository.

- Processed Report. USDA -ARS and Oregon State Univ. Oregon, USA.
- Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

I. Course Title : Genomicsin Plant Breeding*

II. Course Code : GPB605

III. Credit Hours : 3(3+0)

IV. Why this course?

The knowledge of recent trends in plant genomics, genome sequencing, molecular maps, and concepts of high-through put proteomics, metabolomics and phenomics is essential in rapid crop improvement programmes.

V. Aim of the course

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics.

VI. Theory

Unit I

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genomesize and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principle s and techniques of conventional approaches and next generations equencing including sequencing-by-synthesis / ligation and single moleculereal time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing includings hotgun and clone-by-clone method.

Unit III

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allelemining; Diversity array technology: concepts and applications.

Unit IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specifictran scriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hy bridization, RT-PCR, qRT-PCR and molecular beacon.

Unit V

Development and management of database; Applications of bio informatics tools/software in genomics for crop improvement. Basic concepts of high-through put proteomics, metabolomics and phenomics.

Unit VI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement.Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

VII. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning out come

After the completion of this course, the student will have expertise on about different techniques for genome sequencing, molecular maps, and concepts of high-through putproteomics, metabolomics and phenomics in crop improvement

IX. Suggested Reading

Alonso JM, Stepanova AN. 2015. Plant Functional Genomics: Methods and Protocols. Springer.
ChopraVL, Sharma RP, Bhat SR and Prasanna BM.2007. Search for New Genes.Academic Foundation, NewDelhi.

Hackett PB, Fuchs J A and Messing J W. 1988. An Introduction to Recombinant DNA Tech nology-Basic Experimentsin Gene and Manipulation. 2nd Ed. Benjamin PublicationCo.

Primose SB and Twyman RM. 2006. Principles of GeneManipulation and Genomics.7thEd.

Wiley - Black well Publishing.

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

Singh BD. 2005. Biotechnology: Expanding Horizons. Kalyani Publishers, New Delhi.

Somers DJ, Lang ridge P, Gustafson JP. 2009. Plant Genomics: Methods and Protocols. Springer.

e-Resources

http://gramene.org. https://www.arabidopsis.org. https://wheat.pw.usda.gov http://ncbi.nlm.nih.gov http://www.maizegenetics.net

I. Course Title : Population Genetics

II. Course Code : GPB 606

III. Credit Hours : 2(2+0)

IV. Why this course?

Population improvement programmes are the basis of genetic enhancement in cross pollinated crops. This course is needed to make the students aware about the population genetics and its role incrop improvement.

V. Aim of the course

To impart knowledge on structure, properties and their breeding values of different population.

VI. Theory

Unit I

Population : Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure, etc.; Frequencies of genes and geno types; Causes of change: population size, differences in fertility and viability, migration and mutation.

Unit II

Hardy-Weinbergequilibrium, Hardy-Weinberglaw, Proof and applications of the Hardy-Weinber glaw, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non-dominance, Codominance, Snyder's ratio, importance and its effect over random mating in succeeding generations.

Unit III

Multiple alleles, More than one locus, Sex linked genes; Use of gene and geno typic frequencies evaluation in field population level; Interpretations - Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favorin gheter ozygotes; Over dominance for fitness.

Unit IV

Mating systems, Random mating population, Nonr and ommating: selfing-in breeding coefficient, panmictic index, sibmating, Assortative mating and disassortative mating; Pedigree populations and close in breeding, Estimation of linkaged is equilibrium, Correlation between relatives and estimation of F; Effect of in breeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value-Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adaptive organization of gene pools; Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage - Survival of recessive and deleterious all eles in populations.

VII. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Grouptasks, student's presentations

VIII. Learning outcome

After the completion of this course the student will bewellversed with population genetics, its components and application sincrop improvement.

IX. Suggested Reading

- ChawlaV and Yadava RK.2006.Principles of Population Genetics–A Practical Manual. Dept. of Genetics, CCSHAUH isar.
- Falconer DS and Mackay J.1996. Introduction to Quantitative Genetics. Longman.
- Jain JP, Jain J and Parbhakaran VT.1992. Genetics of Populations. South Asia Books.
- LiCC.1955. Population Genetics. The Univ. of Chicago Press.
- Mather K and Jinks JL.1982. Biometrical Genetics.Chapman&Hall.
- Sorrens D and Doniel G. 2007. Method sin Quantitative Genetics. Series: Statistics for Biology and Health. Likeli hood.
- Tomar SS.1992. Text Book of Population Genetics. Universal Publication.

I. Course Title : Crop Evolution

II. Course Code : GPB 607

III. Credit Hours : 3(3+0)

IV. Why this course?

This course imparts knowledge about the origin and evolution of species, centres of diversity, speciation, domestication and significance of polyploidy.

V. Aim of course

To impart knowledge on crop evolution aryaspect sandrole of mutations, hybridizations and polyploidy incropevolution and improvement.

VI. Theory

Unit I

Origin and evolution of species; Centres of diversity/origin, diffusedcentres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity- Characteristics of early domestication and changes–Concept of gene pools and crop evolution; Selection and Genetic drift-Consequences.

Unit II

Speciation and domestication-The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distanthy bridization and introgression, Inter- specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Genetransfer into cultivated species, tools and techniques; Validation of transfer red genes and their expression; Controlled in trogressions.

Unit III

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization- Trans genesis in crop evolution, Multifactorial genome, Intra genomic interaction,

Inter genomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit IV

Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of auto polyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibrecrops, Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

VII. Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning out come

After the completion of this course the student will have knowledge of Origin and evolution of species, Centres of diversity, Speciation, domestication and significance of micro-mutations and polyploidy in genetic improvement of crop plants.

IX. Suggested Reading

- Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
- Ladizin sky G.1999. Evolution and Domestication. Springer.
- Miller AJ. 2007.Crop Plants : Evolution . John Wiley & Sons.
- Smart t J and Simmonds NW.1995.Evolution of Crop Plants. Blackwell.

I. Course Title : Breeding Designer Crops

II. Course Code : GPB 608

III. Credit Hours : 2(1+1)

IV. Why this course?

This course enlightens about developing varieties for specialtraits, physiological efficiency and nutritional enhancement. It gives concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products.

V. Aim of the course

Breeding crops for higher physiological efficiency and nutritional enhancement.

VI. Theory

Unit I

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.

Unit II

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; Breeding for special traits, viz., oil, protein, vitamins, amino acids, etc.; Eco specific ideo types, Ideo types for high and low moisture conditions, low and high input conditions, conversion mechanism of C_3 to C_4 plants; Determination of genetics of above mentioned traits.

Unit III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of sub optimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

Unit IV

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.

Unit V

Bio safety management, segregation and isolation requirements in designer crop production and post-harvest management.

VII. 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/salts hock proteins.

X. Teachning Methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

IX. Learning out come:

Pass outs will have clear understanding of ideo types of crops under varied agro-climatic situations and breed for physiological efficient geno type. C and evelop varieties for special traits having high ther apeutic and nutracetrical value.

X. Suggested Reading

- BalintA.1984.Physiological Genetics of Agricultural Crops. AKAdemiaikiado.
- Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Black well.
- Pessarakli M. 1995. Handbook of Plant and Crop Physiology. Marcel Dekker.
- Taiz Land Zeiger E.2006. Plant Physiology. 4th Ed. Sinauer Associates.

I. Course Title : IPR and Regulatory Mechanism (e-course)*

II. Course Code : GPB 609

III. Credit Hours : 1(1+0)

IV. Why this course?

Biodiversity conservation and its judicious utilization are important in sustainable plant breeding programs. Breeders' and farmers' rights are important inscenario of globalization of agriculture so knowledge of IPRs is essential for a plant breeder to protect his varieties.

V. Aim of the course

The main objective of this course is to equip students and stake holders with knowledge of intellectual property rights (IPR), related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

VI. Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs ; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

VII. Teaching methods

- Power point presentation
- Smart board
- Assignments, quiz
- Group tasks, student's presentations

VIII. Learning out come

The students will have acquaintance of intellectual property rights, national and international laws on biodiversity and sustainable use of plant genetic resources through transfer and sharing. Can assist in follow up of various treatises and laws for research collaborations at international levels.

IX. Suggestedv Reading

Erbisch F Hand MarediaK.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

Intellectual Property Rights: Key to NewWealth Generation. 2001.NRDC & AestheticTechnologies.

Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol.V.Technology Generation and IPR Issues. Academic Foundation.

PLANT PATHOLOGY

Course Course Title with Credit Load
Ph.D. in Plant Pathology

Course Code	Course Title	Credit Hours
PL PATH 601	Advances in Mycology	3(2+1)
PL PATH 602	Advances in Virology	3(2+1)
PL PATH 603	Advances in Plant Pathogenic Prokaryotes	3(2+1)
PL PATH 604**	Molecular Basis of Host-pathogen Interaction	3(2+1)
PL PATH 605	Principles and Procedures of Certification	1(1+0)
PL PATH 606	Plant Biosecurity and Biosafety	2(2+0)

**Core Courses for Doctoral Programme

Course Contents
Ph.D. in Plant Pathology

I. Course Title : Advances in Mycology

II. Course Code : PL PATH 601

III. Credit Hours : 3(2+1)

IV. Aim of the course

To acquaint with the advances in mycology

V. Theory

Unit I

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxnomy. Interaction between groups: Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti.

Unit II

Population biology, pathogenic variability/ vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Unit III

Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

Unit IV

Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nano particles – characterization process and application. Mycotoxins problems and its management.

VI. Practical

- Isolation, purification and identification of cultures, spores and mating type determination;
- Study of conidiogenesis-Phialides, porospores, arthospores;
- Study of fruiting bodies in Ascomycotina;
- Identification of fungi up to species level;
- Study of hyphal anastomosis;
- Morphology of representative plant pathogenic genera form different groups of fungi;
- Molecular characterization of fungi.

VII. Suggested Reading

- Alexopoulos CJ, Mims CW and Blackwell M. 1996. Introductory Mycology. John Wiley & Sons, New York.
- Dube HC. 2005. An Introduction to Fungi. 3rd Ed. Vikas Publ. House, New Delhi.

- Kirk PM, Cannon PF, David JC and Stalpers JA. (Eds.). 2001. Ainsworth and Bisby's Dictio nary of Fungi. 9th Ed., CABI, Wallington.
- Maheshwari R. 2016. Fungi: Experimental Methods in Biology 2nd edn. CRC Press, US.
- Ulloa M and Hanlin RT. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Minnesota. Webster J and Weber R. 2007. Introduction to Fungi. Cambridge University Press, Cambridge.

I. Course Title : Advances in Plant Virology

II. Course Code : PL PATH 602

III. Credit Hours : 3(2+1)

IV. Aim of the course

To educate about the advanced techniques and new developments in plant virology.

V. Theory

Unit I

Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/ strains: mutation, recombination, pseudo- recombination, component re-assortment, etc.

Unit II

Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/ serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

Unit III

Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/ q PCR) and non PCR based: LAMP, Fluorescent in situ hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome- information content, coding and non- coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses and satellite RNA.

Unit IV

Gene expression, regulation and viral promoters.Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/ complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

VI. Practical

- Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation;
- Acquaintance with different serological techniques

  (i) DAC- ELISA (ii) DAS-ELISA

  (iii) DIBA (iv) Western blots

  (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and auto radiography;
- PCR application and viral genome cloning of PCR products, plasmid purification, enzyme diges tion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny);
- Bio informatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

VII. Suggested Reading

- Davies 1997. Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida.
- Fauquet et al. 2005. Virus Taxonomy. VIII Report of ICTV. Academic Press, New York.
- Gibbs A and Harrison B. 1976. Plant Virology – The Principles. Edward Arnold, London.
- Jones P, Jones PG and Sutton JM. 1997. Plant Molecular Biology: Essential Techniques. John Wiley & Sons, New York.
- Khan J A and Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Howarth Press, New York.
- Maramorosch K, Murphy FA and Shatkin AJ. 1996. Advances in Virus Research. Vol. 46. Academic Press, New York.
- Pirone TP and Shaw JG. 1990. Viral Genes and Plant Pathogenesis. Springer Verlag, New York.
- Roger Hull. 2002. Mathew's Plant Virology (4th Ed.). Academic Press, New York.
- Thresh JM. 2006. Advances in Virus Research. Academic Press, New York.

I. Course Title : Advances in Plant Pathogenic Prokaryotes

II. Course Code : PL PATH 603

III. Credit Hours : 3(2+1)

IV. Aim of the course

To learn about the latest developments in all the plant pathogenic prokaryotes as a whole.

V. Theory

Unit I

Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (bacteria) cell wall/ envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden-Meyerhof-Parmas (EMP) pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).

Unit II

Current trends in taxonomy and identification of phytopathogenic prokarya: International code of nomenclature, Polyphasic approach, New/ special detection methods for identification of bacterial plant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and nomenclature.

Unit III

Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

Unit IV

Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/ bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker, etc. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs.

Unit V

Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

VI. Practical

- Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining, Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopatho genic bacteria using species/ pathovar specific primers;
- Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts;
- Important and emerging diseases and their management strategies.

VII. Suggested Reading

- Dale JW and Simon P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York.
- Garrity GM, Krieg NR and Brenner DJ. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.
- Gnanamanickam SS. 2006. Plant-Associated Bacteria. Springer Verlag, New York.
- Mount MS and Lacy GH. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, New York.
- Sigee DC. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge.
- Starr MP. 1992. The Prokaryotes. Vols. I–IV. Springer Verlag, New York.

I. Course Title : Molecular Basis of Host-pathogen Interaction

II. Course Code : PL PATH 604

III. Credit Hours : 3(2+1)

IV. Aim of the course

To understand the concepts of molecular biology and biotechnology in relation to host plant-pathogen interactions.

V. Theory

Unit I

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

Unit II

Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innate immunity: PAMP/ DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

Unit III

Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene- for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

Unit IV

Pathogen population genetics and durability, viruses vs cellular pathogens.Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

VI. Practical

- Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electro phoresis, bacterial transformation;
- Gene mapping and marker assisted selection;
- Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

VII. Suggested Reading

- Chet I. 1993. Biotechnology in Plant Disease Control. John Wiley & Sons, New York.
- Gurr SJ, McPohersen MJ and Bowlos DJ. (Eds.). 1992. Molecular Plant Pathology – A Practical Approach. Vols. I & II, Oxford Univ. Press, Oxford.
- Mathew JD. 2003. Molecular Plant Pathology. Bios Scientific Publ., UK.
- Ronald PC. 2007. Plant-Pathogen Interactions: Methods in Molecular Biology. Humana Press, New Jersey.
- Stacey G and Keen TN. (Eds.). 1996. Plant Microbe Interactions. Vols. I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

I. Course Title : Principles and Procedures of Certification

II. Course Code : PL PATH 605

III. Credit Hours : 1 (1+0)

IV. Aim of the course

To acquaint with the certification procedures of seed and planting material.

V. Theory

Unit I

Introduction to certification. International scenario of certification and role of ISTA,

EPPO, OECD, etc. in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health, etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

Unit II

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

VI. Reference

- Association of Official Seed Certifying Agencies. Hutchins D and Reeves JE. (Eds.). 1997.
- Seed Health Testing: Progress Towards the 21st Century. CABI, UK. ISHI-veg Manual of Seed Health Testing Methods.
- ISHI-F Manual of Seed Health Testing Methods.
- ISTA Seed Health Testing Methods.
- Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Gov ernment of India, New Delhi. US National Seed Health System.

e-Resources

http://www.aosca.org/index.htm. http://www.worldseed.org/enus/international_seed/ishi_vegetable.html http://www.worldseed.org/en-us/international_seed/ishi_f.html/ http://www.seedtest.org/en/content11132241.html http://www.seedhealth.org

I. Course Title : Plant Biosecurity and Biosafety

II. Course Code : PATH 606

III. Credit Hours : 2(2+0)

IV. Aim of the course

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

V. Theory

Unit I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.

Unit II

National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Unit III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/ resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.

VI. Suggested Reading

- Biosecurity: A Comprehensive Action Plan.
- Biosecurity Australia.
- Biosecurity for Agriculture and Food Production.
- FAO Biosecurity Toolkit 2008.
- Grotto Andrew J and Jonathan B Tucker. 2006. Biosecurity Guidance.
- Khetarpal RK and Kavita Gupta 2006. Plant Biosecurity in India – Status and Strategy. Asian Biotechnology and Development Review 9(2): 3963.
- Randhawa GJ, Khetarpal RK, Tyagi RK and Dhillon BS (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.

e-Resources

http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml

www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory http://www.who.int/csr/resources/publications/biosafety/WHO_CD S_EPR_2006.pdf http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf www.biosecurity.govt.nz DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm

www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand. http://www.fao.org/biosecurity/ CFIA.

VII. List of Journals

- Annals of Applied Biology – Cambridge University Press, London
- Annals of Plant Protection Sciences- Society of Plant Protection, IARI, New Delhi
- 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 Plant Protection – Plant Protection Association of India, NBPGR, Hyderabad.
- Indian Journal of Virology – Indian Virological Society, New Delhi
- Indian Phytopathology-Indian Phytopathological Society, IARI New Delhi.
- Journal of Mycology and Plant Pathology – Society of Mycology and Plant Pathology, Udaipur.
- Journal of Plant Disease Science- Association of Plant Pathologists (Central India) PDKV, Akola.
- 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 e-Resources www.shopapspress.org
- www.apsjournals.apsnet.org
- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

SOIL SCIENCE

Course Title with Credit Load
Ph.D. in Soil Science

Course Code	Course Title	Credit Hours
Soil 601	Recent trends in soil physics	2(2+0)
Soil 602	Modern concept in soil fertility	2(2+0)
Soil 603*	Physical chemistry of soil	2(2+0)
Soil 604*	Soil genesis and micromorphology	2(2+0)
Soil 605	Bio-chemistry of soil organic matter	2(2+0)
Soil 606	Soil resource management	3(3+0)
Soil 607	Modelling of soil plant system	2(2+0)
Soil 608	Clay Mineralogy	3(2+1)
Soil 609	Recent trends in soil microbial biodiversity	3(2+1)

*Core Courses for Doctoral Programme

Course Contents
Ph.D. in Soil Science

I. Course Title : Recent Trends in Soil Physics

II. Course Code : Soil 601

III. Credit Hours : 2(2+0)

IV. Aim of the course

To provide knowledge of modern concept sin soil physics.

V. Theory

Unit I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC).

Unit II

Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated waterflow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional waterflow.

Unit III

Theories of horizontal and vertical infiltration under different boundary conditions.

Unit IV

Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Unit V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heatflow, measurement of thermal conductivity of soil; Soil, Plant, Water relations- Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture.

Unit VII

Solar and terrestrial radiation measurement, dissipation and distribution in 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.

VI. Teaching Methods and Activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

VIII. Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
- Hanks and Ascheroft. 1980. Applied Soil Physics. Springer Verlag.
- Hillel D. 1980. Applications of Soil Physics. Academic Press.
- Hillel D. 1980. Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley Interscience.
- Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC. 1994. Soil Physics. Oxford & IBH.

I. Course Title : Modern Concept in Soil Fertility

II. Course Code : Soil 602

III. Credit Hours : 2(2+0)

IV. Aim of the course

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

V. Theory

Unit I

Nutrient availability-concept and relationships, modern concepts of nutrient s availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

Unit III

Chemical equilibria (including solid-solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Unit V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit VII

Carbon– a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

VIII. Suggested Reading

- Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley & Sons.
- Barker V Allen and Pilbeam David J. 2007. Handbook of Plant Nutrition. CRC / Taylor & Francis.
- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Educ.
- Cooke GW. 1979. The Control of Soil Fertility. Crossby Lockwood & Sons.
- Epstein E. 1987. Mineral Nutrition of Plants - Principles and Perspectives. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. Trace Elements in Soils and Plants. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Mortvedt JJ, Shuman LM, CoX FR and Welch RM. (Eds.). 1991. Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur,
- Micronutrients. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. Nitrogen in Agricultural Soils. Soil Science Society of America, Madison.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1990. Soil Fertility and Fertilizers. 5th Ed. Macmillan Publ.
- Wild A. (Ed.). 1988. Russell's Soil Conditions and Plant Growth. 11th Ed. Longman.

I. Course Title : Physical Chemistry of Soil

II. Course Code : Soil 603

III. Credit Hours : 2(2+0)

IV. Aim of the course

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

V. Theory

Unit I

Colloidal chemistry of in organic and organic components of soils–their formation, clay organic interaction.

Unit II

Predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit III

Thermodynamics of nutrient transformations in soils; Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Unit IV

Adsorption/desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit V

Common solubility equilibria-carbonates, ironoxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil chemical behaviour on research for solving field problems.

VIII. Suggested Reading

- Bear RE. 1964. Chemistry of the Soil. Oxford & IBH.
- Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
- Fried M and Broeshart H. 1967. Soil Plant System in Relation to Inorganic Nutrition. Academic Press.
- Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
- Greenland DJ and Hayes MHB. 1978. Chemistry of Soil Constituents. John Wiley & Sons.

- Jurinak JJ. 1978. Chemistry of Aquatic Systems. Department of Soil Science and Biometeorology, Utah State University
- McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.
- Sparks DL. 1999. Soil Physical Chemistry. 2nd Ed. CRC Press.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.
- Sposito G. 1989. The Chemistry of Soils. Oxford University Press.
- Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley.
- van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

I. Course Title : Soil Genesis and Micromorphology

II. Course Code : Soil 604

III. Credit Hours : 2(2+0)

IV. Aim of the course

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

V. Theory

Unit I

Pedogenic evolution of soils; soil composition and characterization.

Unit II

Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Unit III

Assessment of soil profile development by mineralogical and chemical analysis.

Unit IV

Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil micro pedology and soil taxonomy on research for solving field problems.

VIII. Suggested Reading

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
- DiXon JB and Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. Clay Mineralogy. McGraw Hill.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi
- Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.
- USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA and MattoX RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH.

I. Course Title : Biochemistry of Soil Organic Matter

II. Course Code : Soil 605

III. Credit Hours : 2(2+0)

IV. Aim of the course

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

V. Theory

Unit I

Organic matter in soils and its maintenance Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit III

Nutrient transformation–N, P, S; tracemetal interaction with humic substances, significance of chelation reactions in soils.

Unit IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay- organic matter complexes.

Unit V

Humus-pesticide interactions in soil, mechanisms.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on the knowledge of soil biochemistry on research for solving field problems

VIII. Reading Materials

- Lynch JM, Willey JM. Soil Biotechnology.
- Paul EA and Clark FE. Soil Microbiology and Biochemistry
- Sherwood LM and Woolverton CJ. Prescott's Microbiology.
- Subba Rao NS. Advances In Agricultural Microbiology

I. Course Title : Soil Resource Management

II. Course Code : Soil 606

III. Credit Hours : 3(3+0)

IV. Aim of the course

To impart the students basic holistic knowledge on soil resource and latest developments in its sustainable use.

Unit I

Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, genereserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

Unit II

Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

Unit III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and diaralands. Management of forest, peat and muck soils.

Unit IV

Soil conservation planning; land capability classification; soil conservation in special problem are as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control, reclamation of saltaffected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

Unit V

Watershed management-concept, objectives and approach; water harvesting and recycling; flood

control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

Unit VI

Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

V. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VI. Learning outcome

Experience on the knowledge of soil resources on research for solving field problems.

VII. Suggested Reading

- Abrol IP and Dhruvanarayana VV. 1990. Technology for Wasteland Development. ICAR, New Delhi.
- Andriesse JP. 1988. Nature and Management of Tropical Peat Soils, Soil Resources, FAO Soils Bulletin 59, Management and Conservation Service, Land and Water Development Division, FAO, Rome
- Blackwell, Dent D and Young A. 1981. Soil Survey and Land Evaluation. George Allen and Unwin, London.
- Burrough A and McDonnell RK. 1998.Principles of Geographical Information System. Oxford University Press.
- Dan Binkley D and Fisher R. 2012. Ecology and Management of Forest Soils,4th Edition, Wiley.
- FAO. 1996. Land Quality Indicators and their Use in Sustainable Agriculture and Rural Devel opment. FAO Land and Water Bulletin.5. FAO, Rome.
- Faroq M and Siddique K. (Ed.). 2015. Conservation Agriculture, Springer Nature, Chennai, India.
- FESL. 1993. An International Framework for Evaluating Sustainable Land Management, FAO World Soil Resources Report No. 73, Land Development Division, FAO, Rome.
- ISSS. 1994. Management of Land and Water Resources for Sustainable Agriculture and Envi ronment. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi.
- Lal R, Blum WEH, Valentine C and Stewart BA. (Editors). 1988. Methods for Assessment of Soil Degradation. CRC Press, Boca Raton.
- Mulders MA. 1987. Remote Sensing in Soil Science. Elsevier Science Publishers, Amsterdam.
- Sehgal J. 2014. A Text Book of Pedology Concepts and Application. Kalyani publishers, New Delhi.
- SSSA 1996. Methods for Assessing Soil Quality. SSSA Publication Number 49, Madison, Wisconsin, USA.

I. Course Title : Modelling of Soil Plant System

II. Course Code : Soil 607

III. Credit Hours : 2(2+0)

IV. Aim of the course

To train the students in concepts, methodology, technology and use of systems simulations in soil and crop studies.

V. Theory

Unit I

Introduction, terms and definitions; classification of models; Taylor series; numerical methods of differentiation and integration.

Unit II

High level computer language: FORTRAN-its commands and usage; testing and evaluation of model.

Unit III

Description of spatially homogeneous models; K transformation model; nitrogen and phosphorus dynamics in soil.

Unit IV

Spatially heterogeneous models; equation of continuity; Simulation of water flow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method.

Unit V

Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

IV. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on soil modelling concept for forecasting productivity

VIII. Suggested Reading

- Datta SC. 2008. Theory and Principles of Simulation Modeling in Soil-Plant System. Capital Publishing Company, New Delhi.
- Frame J and Thornley JHM. 1984. Mathematical Models in Agriculture—A Quantitative ap proach to problems in agriculture and related science. Butterworth and Co. Ltd.
- Freud PJ and Minton PD. 1979. Regression Methods—A tool for data Analysis. Marcel Dekker Inc., New York.
- Frissel MJ and Reinger P. 1974. Simulation of Accumulation and Leaching in Sils. Oxford and IBM Pub. Co., New Delhi.

- Hanks J and Richie JT. (Eds.). 1991. Modeling Plant and Soil System. Agronomy Bulletin No. 31, ASA, SSSA Madison, Wisconsin, USA.
- Lipschutz S and Poe A. 1978. Schaum's Outline Series–Theory and Problems of programming with Fortran. McGraw-Hill Book Co., Singapore.
- Penning de Vries FWT, Jansen DM, Ten Berge HFM and Baker A. 1989. Simulation of eco physiological processes of growth in several annual crops. PUDOC, Wageningen.
- Shaffer MJ, Ma L and Hansen S. 2001. Modeling Carbon and Nitrogen Dynamics for Soil Management. Lewis Publishers, Boca Raton.

I. Course Title : Clay Mineralogy

II. Course Code : Soil 608

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, external characteristics of crystals, crystallographic notations, crystal systems.

Unit II

Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmitdt's laws – Laws I and Law II, Classification of Phyllosilicates.

Unit III

Kaolonite group of minerals, Dioctahedral kaolins and Trioctahedral kaolins.

Unit IV

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit V

Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite.

Unit VI

Vermicullites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Unit VII

Chlorite: occurrence and structure of chlorites, "swelling chlorites", formation of chlorite.

Unit VIII

Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit IX

Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit X

Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit XI

Surface chemistry of clay minerals, clay-organic complexes, nanoclay mineralogy.

Unit XII

Clay minerals in different soil orders, role of clay minerals in soil fertility management.

V Practicals

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals
- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

VI. Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

VII. Learning outcome

Experience on soil clays and utility in soil research.

VIII. Suggested Reading

- Dixon JB and Weed SB (Co-editors). Minerals in Soil Environment.
- Gieseking JE (Ed). Soil Component, Vol. 2. Inorganic Components.
- Grim RE. Clay Mineralogy.
- Mukherjee SK and Biswas TD (Editors). Mineralogy of Soil Clays and Clay Minerals.
- Read HH. Rutley's Elements of Mineralogy.
- Wilding LP and Smeck NE. 1983. Pedogenesis and Soil Taxonomy Part II – Soil Orders.

I. Course Title : Recent Trends in Soil Microbial Biodiversity

II. Course Code : Soil 609

III. Credit Hours : 3(2+1)

IV. Theory

Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit II

Qualitative ecology of microorganisms; Biomass and activities.

Unit III

Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterising N fixing microorganisms.

Unit IV

Serology and molecular characterization, ecological aspects of bio determination, soil waste and water management

Unit V

Biodegradability, testing and monitoring of the bioremediation of pollutants and bacterial fertilizers.

V. Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

VI. Teaching Methods/Activities

Classroom teaching with AV aids, group discussion, field visit

VII. Learning outcome

Experience on soil microbial diversity and planning for proper utilization.

VIII. Suggested Reading

- Lynch JM, Willey JM. Soil Biotechnology.
- Paul EA and Clark FE. Soil Microbiology and Biochemistry.
- Sherwood LM and Woolverton CJ. Prescott's Microbiology.
- Subba Rao NS. Advances In Agricultural Microbiology.

I. Course Title : Research and Publication Ethics

II. Course Code : Soil 610

III. Credit Hours : 2(2+0)

IV. Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Defination, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals.

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g index, i10 index altmetrics

V. Teaching methods/activities

Classroom teaching with AV aids, group discussion, field, laboratory and library visit

VI. Learning outcome

Quality research output and outstanding research publication with excellent impact factor.

Ph.D. in Forestry

SILVICULTURE AND AGROFORESTRY

Course Title with Credit Load
Ph.D. (Forestry) in Silviculture and Agroforestry

Course Code	Course Title	Credit Hours
SAF 601*	Quantitative Silviculture	3(2+1)
SAF 602*	Agroforestry Research and Management	3(2+1)
SAF 603	Forest Stand Dynamics	1(1+0)
SAF 604	Productivity and Evaluation of Agroforestry Systems	3(2+1)
SAF 605	Forest Stand Management Techniques	2(1+1)
SAF 606	Agroforestry for Ecosystem Services and	2(2+0)
SAF 607	Environmental Benefits Plantation Forest Productivity	2(1+1)
SAF 608	Restoration Forestry	2(1+0)
SAF 609	Regeneration Silviculture	3(2+1)
SAF 610	Forest Soil Management	2(1+1)
SAF 611	Agroforestry for Sustainable Agriculture	1(1+0)

*Core Courses for Doctoral Programme

Course Contents
Ph.D. (Forestry) in Silviculture and Agroforestry

I. Course Title : Quantitative Silviculture

II. Course Code : SAF 601

III. Credit Hours : 3(2+1)

IV. Aim of the course

To educate students with regard to forest stand growth and yield, quantitative techniques used for evaluating site quality, measuring stand density, predicting forest growth and yield.

V. Theory

Unit I

Principles of tree and stand growth and yield. Habitat types; site quality; site index. Growth functions – empirical, exponential, allometry and Backman's growth functions. Growth pattern and growth increment curve. Growth cycle and phases. Quantifying site quality: Methods – tree and stand height data, periodic height growth. Techniques – guide curves, difference equations, parameter prediction.

Unit II

Stand density and stocking, measures of density: –3/2 power rule of self-thinning, point density, competition indices. Control of growing stock to achieve specific management objectives – growth-growing stock relations, Full site occupancy, Onset of competitive interactions. Langsaeter's hypothesis, stand density index and techniques for translating this understanding into rational density management regimes.

Unit III

Techniques: stand density management diagrams and stocking charts. Construction and use of stand density management diagrams. Designing density management regimes to suit specific management objectives.

Unit IV

Predicting growth and yield: normal and empirical yield tables, stand growth and yield equations, stand table projections. Simulation models: whole-stand models, size-class distribution models, single tree/ distance independent and distance- dependent models, process models, linkage of models at different levels. Evaluation, calibration, verification, and validation of forest growth and yield prediction systems. Introduction to existing forest growth and yield simulators.

VI. Practical

- Assessment of growth characteristics;
- Preparation of growth and increment curves;
- Site quality assessment, Stand density diagrams;
- Growth prediction models;
- Yield simulation techniques.

VI. Suggested Reading

- Clutter JL, Fortson JC, Pienaar LV, Brister GH and Bailey RL. 1992. Timber Management: A Quantitative Approach. Krieger Publishing Company.
- Davis LS and Johnson KN. 1987. Forest Management. 3rd Ed. McGraw-Hill.
- Evans J. 1982.
- Plantation Forestry in the Tropics. Clarendon Press.
- Johnson PS, Shifley SR and R. Rogers. 2009. Self-thinning and Stand Density. The Ecology and Silviculture of Oaks. CABI, Cambridge, MA.
- Luna RK. 1989. Plantation Forestry in India. International Book distributors.
- Vanclay JK. 1994. Modeling Forest Growth and Yield: Application to Mixed Tropical Forests. CAB International.

Lecture Schedule

Sr.No.	Topic	No. of Lecture(s)
	Theory	
1.	Principles of tree and stand growth and yield	02
2.	Habitat types; site quality; site index	02
3.	Growth functions – empirical, exponential, allometry and Backman's growth functions	03
4.	Growth pattern and growth increment curve. Growth cycle and phases	02
5.	Quantifying site quality: Methods – tree and stand height data, periodic height growth	02
6.	Techniques – guide curves, difference equations, parameter prediction	02
7.	Stand density and stocking, measures of density: –3/2 power law of self-thinning,	
	point density, competition indices	03
8.	Control of growing stock to achieve specific management objectives –	
	Growth-growing stock relations, Full site occupancy, Onset of competitive	
	interactions. Langsaeter's hypothesis, stand density index and techniques	
	for translating this understanding intorational density management regimes	03
9.	Techniques: stand density management diagrams and stocking charts.	
	Construction and use of stand density management diagrams.	
	Designing density management regimes to suit specific management objectives	03
10.	Predicting growth and yield: normal and empirical yield tables,	
	stand growth and yield equations, stand table projections	03
11.	Simulation models: whole-stand models, size-class distribution models, single tree/	
	distance independent and distance-dependent models, process models, linkage	
	of models at different levels	04
12.	Evaluation, calibration, verification, and validation of forest growth and yield	
	prediction systems. Introduction to existing forest growth and yield simulators	03
	Total	32
	Practical	
1.	Assessment of growth characteristics	2
2.	Preparation of growth and increment curves	3
3.	Site quality assessment, Stand density diagrams	4
4.	Growth prediction models	3
5.	Yield simulation techniques	4
	Total	16

I. Course Title : Agroforestry Research and Management

II. Course Code : SAF 602

III. Credit Hours : 2(2+0)

IV. Aim of the course

To teach how to refine the agroforestry systems, management practices and their integration for developing suitable agroforestry systems.

V. Theory

Unit I

Recent trends in agroforestry research and development. Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry. Multi-functionality of agroforestry systems-multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects. Constraints in agroforestry research – research prioritization.

Unit II

Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations.

Unit III

Introduction to on-farm and on-station research experiments. Biomass production and allocation patterns- changes thorough agroforestry interventions.

Unit IV

Belowground dynamics- role of fine roots in agroforestry productivity. Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability and environmental resource sharing. Site-species compatibility. Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems.

Unit V

Carbon and nutrient dynamics in agroforestry- carbon sequestration- carbon credits-mitigatory and adaptive roles of agroforestry in the climate negotiations and agroforestry.

Unit VI

Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD. Carbon conservation, sequestration, and substitution functions of agroforestry trees. Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethnoforestry systems. Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations. Climate change and reforestation incentive policies.

Unit VII

Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies.

VI. Suggested Reading

- Chin K Ong, Colin Black and Julia Wilson. 2015. Tree-Crop Interactions, 2nd Edition: Agroforestry in a Changing Climate. CAB International.
- Kumar BM and Nair PKR. 2011. Carbon Sequestration Potential of Agroforestry Systems: Oportunities and Challenges. Springer.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer.
- Ong CK and HuXley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF. Snelder DJ and Lasco RD. 2008. Smallholder Tree Growing for Rural Development and
- Environmental Services. Springer Science, Amsterdam.

Lecture Schedule

Sr.No.	Topic	No. of Lecture (s)
	Theory	
1.	Recent trends in Agroforestry research and development	02
2.	Agroforestry land use systems and their salient features. Research designs and analysis in agroforestry	02
3.	Multifunctionality of agroforestry systems – multiplicity of products and services, food and nutritional security, livelihood security, gender related aspects	02
4.	Constraints in agroforestry research – research prioritization	02
5.	Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations	02
6.	Introduction to on farm and on station research experiments	01
7.	Biomass production and allocation patterns- changes thorough agroforestry interventions	01
8.	Belowground dynamics- role of fine roots in agroforestry productivity	02
9.	Tree husbandry practices in agroforestry for productivity optimization. Soil-site sustainability andenvironmental resource sharing. Site-Species compatibility	02
10.	Competition, predation, mutualism, commensalisms. Simulation modeling of agroforestry systems	02
11.	Carbon and nutrient dynamics in agroforestry- carbon sequestration - carbon credits- mitigatory and adaptive roles of agroforestry in the context of climate change- climate negotiations and agroforestry	02
12.	Management of multifunctional agroforestry – sustainability, links with UNFCCC, UNCCD and UNCBD	02
13.	Carbon conservation, sequestration, and substitution functions of agroforestry trees	02
14.	Domestication of useful species and crafting market regimes for the products derived from agroforestry and ethnoforestry systems	02
15.	Contract fuel wood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations	02
16.	Climate change and reforestation incentive policies	02
17.	Market intelligence for agroforestry products. Agroforestry value chain models: consortia concepts. Successful case studies	02
	Total	32

I. Course Title : Forest Stand Dynamics

II. Course Code : SAF 603

III. Credit Hours : 1(1+0)

IV. Aim of the course

The purpose is to help silviculturists and forest managers to understand and anticipate how forests grow and respond to intentional manipulations and natural disturbances.

V. Theory

Unit I

Introduction-plant interactions and limitations of growth – mutualism and competition – the niche – limitations of growth – concept of growing space.

Unit II

Tree architecture and growth- general growth patterns – shoot development patterns, crown shapes, height growth, root growth, and tree development.

Unit III

Disturbances and stand development – impact of disturbances – major and minor- classification of disturbances – characteristics of disturbance agents. Stand structure and fire behaviour. Building resilience to disturbances.

Unit IV

Overview of stand development patterns – temporal and spatial patterns of tree invasion – stand initiation stage – stem exclusion stage – understorey reinitiation stage – old growth stage – multicohort stands – behaviour of component cohorts- development of multicohort stands – quantification of stand development – forest patterns over long times and large areas. Gap dynamics.

VI. Suggested Reading

- Dagar JC, Tewari JC and Prasad V. 2018. Agroforestry Anecdotal to Modern Science. Springer.
- Daniel TW, Helms JA and Baker FS. 1979. Principles of Silviculture, 2nd edition, McGraw-Hill, 2nd ed.
- Kimmins JP. 1997. Forest Ecology, Macmillan Publishing Company, New York Upper Saddle River, Prentice Hall.
- Koop H. 1989. Forest Dynamics Silvi-star: A Comprehensive Monitoring System. Springer-verlag. New York.
- Oliver CD and Larson BC. 1996. Forest Stand Dynamics. John Wiley & Sons, Inc. New York New York: John Wiley & Sons, Inc.
- Smith DM. 1986. The Practice of Silviculture, 8th ed, Wiley, New York.
- Waring RH and Schlesinger WH. 1985. Forest ecosystems: Concepts and management, Aca demic. Press, San Diego.

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Introduction – plant interactions and limitations of growth – mutualism and competition- the niche – limitations of growth – concept of growing space	03
2.	Tree architecture and growth- general growth patterns – shoot development patterns, crown shapes, height growth, root growth, and tree development	03
3.	Disturbances and stand development – impact of disturbances – major and minor- classification of disturbances – characteristics of disturbance agents	03
4.	Stand structure and fire behaviour. Building resilience to disturbances	03
5.	Overview of stand development patterns – temporal and spatial patterns of tree invasion –stand initiation stage – stem exclusion stage –understorey reinitiation stage – old growth stage	02
6.	Multicohort stands – behaviour of component cohorts- development of multicohort stands – quantification of stand development – forest patterns over long times and large areas. Gap dynamics	03
	Total	17

I. Course Title : Productivity and Evaluation of Agroforestry Systems

II. Course Code : SAF 604

III. Credit Hours : 3(2+1)

IV. Aim of the course

To acquaint the students with concepts in agroforestry systems productivity, managing the factors of production and sustained yield levels.

V. Theory Unit I

Concept of crop productivity. Productivity potential in relation to light, water and nutrients.

Unit II

System complementarity, supplementarity, competitiveness, sustainability and management techniques. Tree root architecture, re-allocation of resources within the plant system.

Unit III

Biological yield and harvest index. Growth and yield functions. Land equivalent ratio. Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield.

Unit IV

Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems.

Unit V

Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry. Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV.

Unit VI

Financial, economic and social accounting of agroforestry projects. Advances in marketing management of agroforestry products. Evaluating combined productivity and profitability of different agroforestry systems vis-a-vis other competitive agro- based systems. Tree insurance schemes.

VI. Practical

- Techniques for leaf area index;
- Photosynthetically active radiation ;
- Soil moisture and leaf water potential;
- Canopy density measurements;
- Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations;
- Socio-economic and financial evaluation of agroforestry projects.

VII. Suggested Reading

- Alavalapati JRR and D Evan Mercer. 2004. Valuing Agroforestry Systems: Methods and appli cations, Kluwer Academic Publishers.
- Kant Shashi and Janaki Alavalapati. 2014. Handbook of Forest Resource Economics, Publisher: Routledge.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer. Nair PKR. 1993. An Introduction to Agroforestry. Kluwer.
- Ong CK and Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF. Sullivan, Gregory M, Susan M Hoke and Jefferson M Fox (editors). 1992. Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu. Hawaii. USA. July 1991. Paia, Ill: Nitrogen Fixing Tree Association.
- Tejwani KG 1994. Agroforestry in India Oxford and IBH publishing Co. Pvt.Ltd.

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Concept of crop productivity. Productivity potential in relation to light, water and nutrients	02
2.	System complementarily, supplementarity, competitiveness, sustainability and management techniques	03
3.	Tree root architecture, reallocation of resources within the plant system	02
4.	Biological yield and harvest index. Growth and yield functions. Land equivalent ratio	03
5.	Water use efficiency, photosynthetic efficiency, radiation balance, canopy transmissivity, canopy management, plant geometry and crop yield	03
6.	Allelopathic effects. Strategies to improve the efficiency and productivity of different land use systems	03
7.	Role of various financing agencies in agroforestry and critical evaluation of different credit systems with emphasis on agroforestry	03
8.	Methodologies for evaluating agroforestry hedonic pricing, PES, LER and LEV	03
9.	Financial, economic and social accounting of agroforestry projects	04
10.	Advances in marketing management of agroforestry products	02
11.	Evaluating combined productivity and profitability of different agroforestry systems vis-a- vis other competitive agrobased systems	03
12.	Tree insurance schemes	01
	Total	17
Sr. No	Topic	No. of Practical(s)
	Practical	
1.	Techniques for leaf area index, photosynthetically active radiation, soil moisture and leaf water potential and canopy density measurements. Exercises on developing alternative optimal agroforestry plans under perfect and imperfect knowledge situations.	6 6
2.	Socio-economic and financial evaluation of agroforestry projects.	4
	Total	16

I. Course Title : Forest Stand Management Techniques

II. Course Code : SAF 605

III. Credit Hours : 2(1+1)

IV. Aim of the course

To develop understanding of students about advances in silviculture and silvicultural practice, effect of silvicultural practices on forest stand management and stand development, advances in coppice silviculture.

V. Theory

Unit I

Philosophy of silviculture – advance reproduction methods and their role in silviculture – Judging successful establishment; Analysis of active and passive site preparation – Silviculture with an ecosystem approach.

Unit II

Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest.

Unit III

Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management. Silvicultural use of prescribed fire. Mechanization and role in silviculture.

Unit IV

Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; mixed plantation forestry, Precision silviculture, silviculture of intensively managed plantations, silviculture for climate change mitigation. Sewage silviculture. Silviculture management for watershed and catchment areas. Silviculture for wildlife habitat improvement.

Unit V

Adjusting silviculture to meet industrial demands – silviculture in perspective – Problem solving procedure for silviculture – silviculture in retrospect.

VI. Practical

- Study of components of silvicultural system for sustained yield;
- Management strategies for even aged and uneven aged stands;
- Choice of site preparation methods, Plantation map, Quality planting stock, Planning for tree planting, Release cutting operation;
- Selection of thinning methods, Intensity of thinning;
- Analysis of site quality and biomass production for timber, pulp wood and fuel wood species;
- Problems in silviculture in tropical, subtropical plantation and their solutions.

VII. Suggested Reading

- Brang P, Spathelf P, Larsen JB, Bauhus J, Bonèina A and Chauvin C. 2014. Suitability of Close-To-Nature Silviculture for Adapting Temperate European Forests to Climate Change. Forestry.
- Colak AH, Rotherham ID and Calikoglu M. 2003. Combining 'Naturalness Concepts' with Close- to-Nature Silviculture. Forstwiss. Centralbl. 122, 421–431.
- Cole DN and Yung L. (eds) 2010. Beyond Naturalness: Rethinking Park and Wilderness Stew ardship in an Era of Rapid Change. Island Press.
- Daniel TW, Helms JA and Baker FS. 1979. Principles of Silviculture, 2nd edition, McGraw-Hill, 2nd ed.
- Fettig CJ, Reid ML, Bentz BJ, Sevanto S, Spittlehouse DL and Wang T. 2013. Changing climates, changing forests: A western North American perspective.

- Franklin JF. 1989. Towards a New Forestry. Am. For.
- Holm-Nielsen LB, Nielsen IC and Balsev H. (eds.) 1989. Tropical Forests, Academic Press, London.
- Pukkala T and Gadow KV. 2012. Continuous Cover Forestry. 2nd Edition Springer.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. The Practices of Silviculture: Applied Forest Ecology. John Wiley & Sons.

	Lecture Schedule	
Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Philosophy of silviculture – Advance reproduction methods and their role in silviculture -judging successful establishment	01
2.	Analysis of active and passive site preparation -silviculture with an ecosystem approach	01
3.	Advances in silvicultural practices; tropical forest, sub-tropical forest and temperate forest	02
4.	Analysis of different techniques of silviculture in forest stand management, technique for early stand development	01
5.	Analysis of thinning methods and its impact on wood yield and quality	01
6.	Stand protection and health management. Silvicultural use of prescribed fire	01
7.	Mechanization and role in Silviculture	01
8.	Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad	02
9.	MiXed plantation forestry, Precision Silviculture, Silviculture of intensively managed plantations	01
10.	Silviculture for climate change mitigation. Sewage silviculture	01
11.	Silviculture management for watershed and catchment areas	01
12.	Silviculture for wildlife habitat improvement	01
13.	Adjusting silviculture to meet industrial demands-silviculture in perspective – Problem solving procedure for silviculture -silviculture in retrospect	02
	Total	16
Sr. No	**Topic**	**No. of Practical(s)**
	Practical	
1.	Study of components of silvicultural system for sustained yield	3
2.	Management strategies for even aged and uneven aged stands	3
3.	Selection of thinning methods, Intensity of thinning	3
4.	Analysis of site quality and biomass production for timber, pulp wood and fuel wood species	3
5.	Problems in silviculture in tropical, subtropical plantation and their solutions	4
	Total	16

I. Course Title : Agroforestry for Ecosystem Services and Environmental Benefits

II. Course Code : SAF 606

III. Credit Hours : 2(2+0)

IV. Aim of the course

To develop understanding of students about ecosystem services and environmental benefits and quantification of ecosystem services and their valuation.

V. Theory

Unit I

Multifunctionality of agroforestry. Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview.

Unit II

Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems. Estimates of carbon sequestration potential – measurement – prospects and problems. Factors affecting above and belowground carbon sequestration potential.

Unit III

Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N2 fixation, mycorrhizal associations. Soil and water conservation benefits.

Unit IV

Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species. Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution.

Unit V

Private profitability vs. social profitability – exclusion or inclusion of social benefits and costs and non-market values, or externalities. Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices.

Valuing environmental services. Profitability of timber-based agroforestry systems. Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs.

VI. Suggested Reading

- Alavalapati JRR, Shrestha RK, Stainback GA and Matta JR. 2004. Agroforestry development: An environmental Economic Perspective. Agroforestry Systems. 61: 299–310.
- Huxley P. 1999. Tropical Agroforestry. Blackwell.
- IPCC. 2007. "Climate Change 2007". Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- Jain SK and Singh P. 2000. Economic Analysis of Industrial Agroforestry: Poplar (Populus

deltoides) In Uttar Pradesh (India). Agroforestry Systems. 49: 255–273.

- Jeffers JNR. 1978. An Introduction to System Analysis with Ecological Application. Edward Arnold.
- Jose S. 2009. Agroforestry for Ecosystem Services and Environmental Benefits: An Overview.
- Agroforestry Systems. 76: 1-10.
- Lyngbaek AE, Muschler RG and Sinclair FL. 2001. Productivity and Profitability of Multistrata Organic Versus Conventional Coffee Farms in Costa Rica. Agroforest. Syst. 53: 205–213.
- Nair PKR. 1993. An Introduction to Agroforestry. Kluwer, Netherlands.
- Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods, CABI, Wallingford, UK.
- Young A. 1997. Agroforestry for Soil Management. 2nd ed. CABI, Wallingofrd, UK.

Lecture Schedule

Sr. No.	Topic	No. of Lecture(s)
	Theory	
1.	Multifunctionality of agroforestry	01
2.	Major ecosystem services and environmental benefits and international conventions and charters on climate change (UNFCCC, UNCCD, agroforestry and climate change negotiations: CoP) and biodiversity conservation (CBD) – an overview	04
3.	Agroforestry for carbon conservation, sequestration, substitution – role and potentials of various agroforestry systems	03
4.	Estimates of carbon sequestration potential-measurement-prospects and problems. Factors affecting above and belowground carbon sequestration potential	04
5.	Agroforestry for soil enrichment – mechanisms – litter and fine root dynamics, rhizo-deposition and other rhizosphere effects, symbiotic and free-living N_2 fixation, mycorrhizal associations. Soil and water conservation benefits	03
6.	Agroforestry for biodiversity conservation. Synergy with climate change mitigation. Landscape connectivity for wildlife, supporting the pollinators of plant species	03
7.	Agroforestry for improved air and water quality. Non-point source pollution in Indian agro-ecosystems. Riparian buffers for alleviating agricultural non-point source pollution	03
8.	Private profitability vs. social profitability – exclusion or inclusion of social benefits and costs and nonmarket values, or externalities	03
9.	Theory of externalities, effect of environmental costs and benefits on the profitability of agroforestry practices	02
10.	Valuing environmental services. Profitability of timber-based agroforestry systems	03
11.	Costs and benefits in agroforestry- valuation of inputs and outputs- environmental outputs	03
	Total	32

I. Course Title : Plantation Forest Productivity

II. Course Code : SAF 607

III. Credit Hours : 2(1+1)

IV. Aim of the course

To develop understanding of students about plantation forest productivity, dynamics of plantation growth, thinning and fertilization of plantation.

V. Theory

Unit I

Plantation forests – scope and perspectives, international and national scenario.

Unit II

Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply.

Unit III

Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations. Tending and cultural operations and plantation productivity – prospects of mechanization in tropical plantations. Reduced impact logging. Clonal forests, their management and productivity comparisons.

Unit IV

Productivity decline in plantation forests – second rotation decline – harvest related resource export – Modern silvicultural interventions.

Unit V

Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives.

VI. Practical

- Plantation productivity analysis – growing stock and MAI assessment – stand density estimation;
- Fertilizers and fertilizer application in plantation;
- Response of plantation to irrigation;
- Productivity of clonal forestry;
- Modern tools in site preparation;
- Weed management methods;
- Management strategies for enhancing plantation productivity.

VII. Suggested Reading

- Evans J and Turnbull JW. 2004. Plantation Forestry in the Tropics: The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes. OUP Oxford.
- Evans J. 1982. Plantation Forestry in the Tropics. Clarendon Press. Ford ED. 1984. Nutrition of Plantation Forests. Academic Press.
- Krishnapillay B. 2000. Silviculture and Management of teak plantations. Unasy. 201. 51:14- 21p.

- Nambiar EKS, Cossalter C and Tiarks A. 1998. Site Management and Productivity in Tropical Plantation Forests. Workshop Proceedings, South Africa.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.
- Smith DM. 1980. The Practice of Silviculture. 8th ed., John Wiley & Sons.
- Suzuki K, Ishii K, Sakurai S and Sasaki S. 2006. Plantation Forestry in the Tropics. Springer Tokyo.
- Zobel BJ, Wyk G and Stahlper P. 1987. Growing Exotic Forests. John Wiley & Sons.

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Plantation forests – scope and perspectives, international and national scenario	02
2.	Dynamics of plantation growth – site quality, stand density, dynamics of nutrient cycling, thinning, spacing and crown efficiency, nutrient pools and dynamics, biological factors in nutrient supply	03
3.	Advances in site preparation techniques. Recent trends in fertilization and irrigation of plantations	02
4.	Tending and cultural operations and plantation productivity – prospects of mechanization in tropical plantations	02
5.	Reduced impact logging	01
6.	Clonal forests, their management and productivity comparisons	02
7.	Productivity decline in plantation forests - second rotation decline - harvest related resource export – Modern silvicultural interventions	02
8.	Project formulation, designing and appraisal of different kinds of plantations to meet specific objectives	03
	Total	17
	Practical	
1.	Plantation productivity analysis – growing stock and MAI assessment – stand density estimation	3
2.	Fertilizers and fertilizer application in plantation, response of plantation to irrigation	3
3.	Productivity of clonal forestry, modern tools in site preparation	4
4.	Weed management methods	2
5.	Management strategies for enhancing plantation productivity	4
	Total	16

I. Course Title : Restoration Forestry

II. Course Code : SAF 608

III. Credit Hours : 1(1+0)

IV. Aim of the course

To develop understanding of students about advances in restoration forestry and forest landscape restoration.

V. Theory

Unit I

Introduction to restoration forestry, scope and opportunities for forest restoration, Natural regeneration, forest and land degradation in the Asia-Pacific region. Forest restoration techniques, tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.

Unit II

Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation, measures to improve resilient and genetically diverse forests. Mangrove restoration.

Unit III

Case studies on successful forest landscape restoration.

VI. Suggested Reading

- Beatty CR, Cox NA and Kuzee ME. 2018. Biodiversity Guidelines for Forest Landscape Restoration Opportunities Assessments. First edition. Gland, Switzerland: IUCN.
- Blakesley D and Buckley P. 2016. Grassland Management and Restoration. Conservation hand books. Pelagic Publishing. Food and Agriculture Organization of the United Nations.
- Chokkalingam U, Shono K, Sarigumba MP, Durst PB and Leslie R. (eds). 2018. Advancing the Role of Natural Regeneration in Large-Scale Forest and Landscape Restoration in the Asia-Pacific Region. FAO and APFNet. Bangkok.
- FAO. 2010. Forests Beneath the Grass. Proceedings of the Regional Workshop on Advancing The Application of Assisted Natural Regeneration for Effective Low-Cost Forest Restoration. Bangkok, FAO.
- FAO/ RECOFTC. 2016. Forest Landscape Restoration in Asia-Pacific Forests. by Appanah, S. (ed.). Bangkok, Thailand.198p
- Prober SM, Byrne M, McLean EH, Steane DA, Potts BM, Vaillancourt RE and Stock WD. 2015. Climate-Adjusted Provenancing: A Strategy for Climate-Resilient Ecological Restoration. Frontiers in Ecology and Evolution, 23 June.

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Introduction to restoration forestry, scope and opportunities for forest restoration	01
2.	Natural regeneration, forest and land degradation in the Asia Pacific region	02
3.	Forest restoration techniques	02
4.	Tools for prioritization, decision-making and monitoring to enhance restoration success, The Bonn Challenge, The Bonn Challenge in Asia, Africa and Latin America.	03
5.	Forest landscape restoration, environment for natural regeneration in forest and landscape restoration, economic and social aspects for successful integration of natural regeneration in forest landscape restoration, adaptive management for forested landscapes in transformation	03
6.	Measures toimprove resilient and genetically diverse forests Mangrove restoration	02 01
7.	Case studies on successful forest landscape restoration	03
	Total	17

I. Course Title : Regeneration Silviculture

II. Course Code : SAF 609

III. Credit Hours : 3(2+1)

IV. Aim of the course

To develop understanding of students about advances in regeneration silviculture, forest continuum, advancement in artificial regeneration.

V. Theory

Unit I

Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques.

Unit II

Basic Concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration. Factors affecting natural and artificial regeneration- kinds, extent and quality of sites.

Unit III

Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment. Regeneration survey and methodology. Major silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry. Advances in coppice silviculture. Silviculture in a changing world.

Unit IV

Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment techniques for production of quality planting stock. Integrated nutrient management in nursery production. Plant quality assessment tools. Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region.

Unit V

Sustainable site establishment practices, Novel tree establishment techniques. Regeneration problems of important conifers and broad leaved species-case studies.

VI. Practical

- Factors affecting natural and artificial regeneration;
- Advances in vegetative propagation techniques like mini and micro-cutting techniques;
- Production technology for quality planting stock;
- Carbon enrichment techniques for production of quality planting stock;
- Integrated nutrient management in nursery production;
- Novel tree establishment techniques. Modern approaches in containerized seedling production.

VII. Suggested Reading

- Colak AH, Rotherham ID and Calikoglu M. 2003. Combining 'naturalness concepts' with close-to-nature silviculture. Forstwiss. Centralbl. 122, 421–431.
- Sairll PS, Evans J, Auclair D and Flack J. 1997. Plantation Silviculture in Europe. Oxford University Press.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. The Practices of Silviculture: Applied Forest Ecology. John Wiley & Sons.

Lecture Schedule

Sr. No.	Topic	No. of Lecture(s)
	Theory	
1.	Planning for regeneration, setting the objectives for regeneration, principles and methodologies of forest regeneration, ecological basis of natural regeneration techniques	03
2.	Basic concepts in forest regeneration, importance of different combinations of light, moisture, soil in determining success or failure of regeneration	03
3.	Factors affecting natural and artificial regeneration- kinds, extent and quality of sites	02
4.	Techniques of canopy manipulation and forest continuum in regular and irregular forests canopy, light pattern and regeneration establishment	03
5.	Regeneration survey and methodology	02
6.	Major Silvicultural systems of tropical and temperate parts of the world. Continuous cover forestry	02
7.	Advances in coppice Silviculture. Silviculture in a changing world	02

8.	Advances in artificial regeneration techniques, advances in vegetative propagation techniques like mini and micro-cutting techniques, production technology for quality planting stock, carbon enrichment	02
9.	Techniques for production of quality planting stock. Integrated nutrient management in nursery production	02
10.	Plant quality assessment tools	04
11.	Nursery production system of important timber and Non-Timber Forest Products, NTFP's yielding species in the region	02
12.	Sustainable site establishment practices, Novel tree establishment techniques	02
13.	Regeneration problems of important conifers and broad leaved species-case studies	03
	Total	32
	Practical	
1.	Factors affecting natural and artificial regeneration,	2
2.	Advances in vegetative propagation techniques like mini and micro-cutting techniques,	3
3.	Production technology for quality planting stock,	3
4.	Carbon enrichment techniques for production of quality planting stock,	2
5.	Integrated nutrient management in nursery production.	2
6.	Novel tree establishment techniques.	2
7.	Modern approaches in containerized seedling production.	2
	Total	16

I. Course Title : Forest Soil Management

II. Course Code : SAF 610

III. Credit Hours : 2(1+1)

IV. Aim of the course

To develop understanding of students about advances in forest soil management, forest soils and vegetation management.

V. Theory

Unit I

Forest soils and vegetation development. Physical properties of forest soils. Forest soil classification. Soils of the major forest biomes – soils under different forest types – tropical rainforest soils – moist deciduous forests – dry deciduous. Soils and plant roots.

Unit II

Soil chemistry and nutrient uptake. Soil organic matter – maintenance and buildup. Biology of forest soils – role of microorganisms in ameliorating soils; N and C cycles. Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils.

Unit III

Nutrient transformation in soils. Nitrogen fixation in tropical forest plantations: N_2 fixation process, species, rates of N_2 fixation, factors influencing N_2 fixation; nutrient cycling – comparison of plantation productivity – case studies. Nutrition management: nutrient limitations, fertilization. Soil carbon sequestration – processes and mechanisms.

Unit IV

Soil management for reforestation of salt affected soils, acid soils, coastal soils. Effects of fire on soils and their properties.

Unit V

Management of long term soil productivity – soil compaction and erosion – harvest removal and nutrient budgeting – harvest effect on water quality – strategies for future management.

VI. Practical

- Nutrient budgeting for different plantation systems;
- Quantification of physical and chemical soil constraints in plantation and agroforestry systems;
- Evolving new strategies for soil and site development.

VII. Suggested Reading

- Binkley D and R. Fisher. 2012. Ecology and Management of Forest Soils (4th Edition), John
- Wiley & Sons Singapore Pte. Ltd., Singapore.
- Fisher RF, Binkley D and Pritchett WL. 2000. Ecology and Management of Forest Soils. 3rd Ed.John Wiley & Sons Inc., New York.
- Havlin et al. 2014. Soil Fertility and Fertilizers: An Introduction to Nutrient Management (8th Edition), PHI Learning Pvt. Ltd., Delhi.
- Khan TO. 2013 Forest Soils: Properties and Management, Springer International Publishing, Switzerland.
- Pritchett and Fisher RF 1987. Properties and Management of Forest Soils. John Wiley, New York.
- Reddy MV. 2001. Management of Tropical Plantation Forests and Their Soil Litter System-Litter, Biota and Soil Nutrient Dynamics. Science Publishers, U.S.
- Sadanandan Nambiar EK and Grown AG. (Eds.). 1997. Management of Soil, Nutrients and Water in Tropical Plantation Forests. ACIAR, CSIR and CIFOR, Australia.
- Schulte A and Ruhiyat D. 1998. Soils of Tropical Forest Ecosystems: Characteristics, Ecology, and Management. Springer Verlag,Berlin, New York.

Lecture Schedule

Sr. No.	Topic	No. of Lecture(s)
	Theory	
1.	Forest soils and vegetation development	01
2.	Physical properties of forest soils, Forest soil classification	01
3.	Soils of the major forest biomes – soils under different forest types –	
	tropical rainforest soils – moist deciduous forests – dry deciduous	01
4.	Soils and plant roots, Soil chemistry and nutrient uptake	01
5.	Soil organic matter – maintenance and buildup	01
6.	Biology of forest soils – role of microorganisms in ameliorating soils;N and C cycles	01
7.	Forest biogeochemistry. Micorrhizae. Role of forests in conserving soils	01
8.	Nutrient transformation in soils	01
9.	Nitrogen fiXation in tropical forest plantations: N2 fiXation process,	
	species, rates of N fiXation, factors influencing N2 fiXation	01
10.	Nutrient cycling – comparison of plantation productivity – case studies	01
11.	Nutrition management: nutrient limitations, fertilization	01
12.	Soil carbon sequestration – processes and mechanisms	01
13.	Soil management for reforestation of salt affected soils, acid soils, coastal soils	01
14.	Effects of fire on soilsand their properties	01
15.	Management of long term soil productivity – soil compaction and	
	erosion – harvest removal and nutrient budgeting	01
16.	Harvest effect on water quality – strategies for future management	01
	Total	16
	Practical	
1.	Nutrient budgeting for different plantation systems,	5
2.	Quantification of physical and chemical soil constraints in plantation	
	and agroforestry systems,	6
3.	Evolving new strategies for soil and site development	5
	Total	16

I. Course Title : Agroforestry For Sustainable Agriculture

II. Course Code : SAF 611

III. Credit Hours : 1(1+0)

Aim of the course

To develop understanding of students about the role of agroforestry in sustainable agriculture, current agricultural scenario, role of trees in enhancing productivity of agricultural land on sustainable basis.

IV. Theory

Unit I

Current Agricultural scenario in India. Sustainable agriculture: issues and challenges. Land use changes- agroforestry: an opportunity for sustainability and rainfed agriculture.

Unit II

Agroforestry options for sustainable agriculture: integration of perennial components in agriculture. Role of trees in enhancing the productivity of traditional agriculture. Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization.

Unit III

Agroforestry for different land holdings. Integrated farming systems. Agroforestry strategies for short term and long term returns.

Unit IV

Processing, value addition and marketing of agroforestry products.

V. Suggested Reading

- Chin K Ong, Colin Black and Julia Wilson. 2015. Tree-Crop Interactions, 2nd Edition: Agroforestry in a Changing Climate. CAB International ICRAF.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer.
- Nair PKR. 1993. An Introduction to Agroforestry. Kluwer, Netherlands.
- Ong CK and Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach.
- Schroth G and Sinclair F. 2003. Tree Crops and Soil Fertility: Concepts and Research Methods. CABI, Wallingford, UK.
- Snelder DJ and Lasco RD. 2008. Smallholder Tree Growing for Rural Development and Envi ronmental Services. Springer Science, Amsterdam.

Lecture Schedule

Sr. No.	Topic	No. of Lecture (s)
	Theory	
1.	Current Agricultural scenario in India. Sustainable agriculture: Issues and challenges and land use changes	02
2.	Agroforestry: An opportunity for sustainability and rainfed agriculture	02
3.	Agroforestry options for sustainable agriculture: Integration perennial components in agriculture	02
4.	Role of trees in enhancing the productivity of traditional agriculture	01
5.	Strategies on integration of trees suitable for different cropping systems for important agro-ecological regions. Tree management for productivity optimization	03
6.	Agroforestry for different land holdings. Integrated farming systems	02
7.	Agroforestry strategies for short term and long term returns	02
8.	Processing, value addition and marketing of agroforestry products	03
	Total	17

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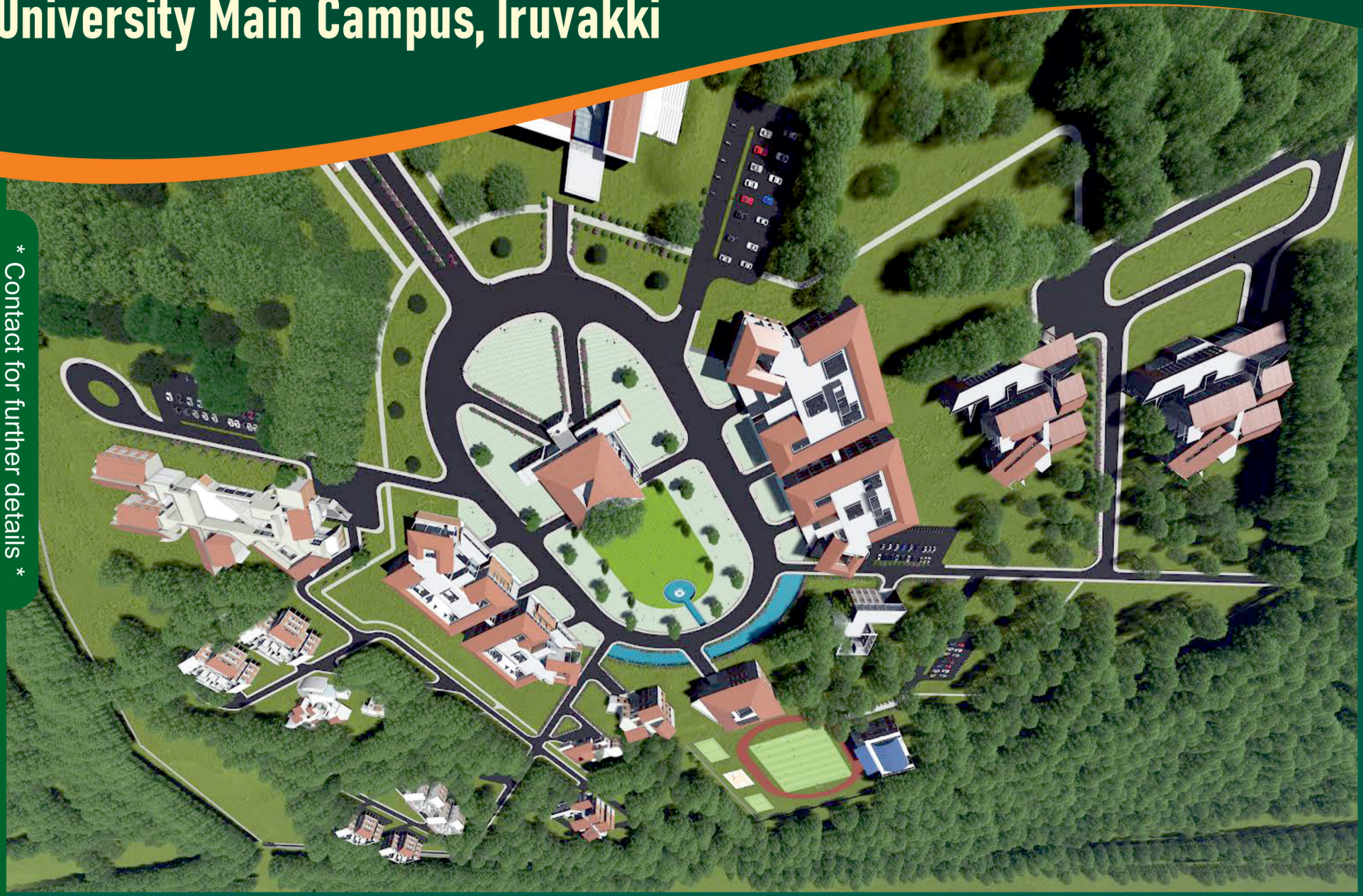

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