UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU

Course Syllabus for Ph. D. Programme

SEMESTER SYSTEM

2016-17

OFFICE OF THE DEAN OF POSTGRADUATE STUDIES
University of Agricultural Sciences
GKVK, Bengaluru-560 065

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DEAN OF POST GRADUATE STUDIES
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AGRICULTURAL ECONOMICS

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AEC 603	Advanced Econometrics	0+1
AEC 604	Advanced Production Economics	1+1
AEC 605	Quantitative Development Policy Analysis	1+1
AEC 606	Advanced Agricultural Marketing and Price Analysis	1+1
AEC 607	Advanced Natural Resource and Environmental Economics and Policy	1+1
AEC 608	Operations Research	0+1
AEC 609	International Trade	0+1
AEC 610	Advanced Institutional Economics and Evolution of Economic Thought	1+1
AEC 611	Advanced Agricultural Financial Management	1+1
AEC 671	Qualifying Examination	3
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AEC 601 *Advanced Micro Economic Analysis* (1+1)

Theory

Theory of consumer behaviour – Duality in consumer theory, expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers' Welfare – Consumer's Surplus, Compensating Variation and Equivalent Variation. Dynamic versions of demand functions – Integrability of demand functions. Demand Models – Linear Expenditure System, Almost Ideal Demand System. Applications of consumer theory – Household model and time allocation – Labour supply decisions by households. Perfect competition. Monopoly, monopolistic competition and oligopoly.

Oligopoly models – collusive and non-collusive models of oligopoly - Cournot model, Chamberlin model, Stackleberg solution. General equilibrium theory – Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Walrasian general equilibrium – Mathematical derivation of conditions for general equilibrium. Market failure - Incomplete markets - Asymmetric information (Principal- Agent problem), adverse selection and moral hazard. Externalities – Network externalities. Public goods – Optimal provision of public goods. Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics. Pareto conditions of maximum welfare – Criteria for social welfare, Social Welfare functions, Social versus Private costs and benefits.

Practical

Problems in consumer utility maximization – Estimation of income and substitution effects; Estimation and comparison of Consumer's surplus, equivalent variation and compensating variation. Estimation of demand models – Derivation and estimation of labour supply equations from household models, comparative static analysis in consumption. Advanced problem solving in price determination under perfect competition, monopoly, oligopoly and monopolistic competition. Game theory models. Problems solving in General Equilibrium Theory and Welfare Economics. Problems in public goods provision.

AEC 602 *Advanced Macro Economics Analysis* (2+0)

Theory

Review of Macro Economics concepts-Comparative statistics, Keynesian theory, Consumption Function and Theories of Consumption- Saving Function and Theories of Saving. Theories of Investment Savings and Investment Equality. IS - LM Framework, demand for and Supply of Money-Monetary Policy in the static model – Inflation, Stagflation and Supply side Economic. Theory of Unemployment- Phillips Curve controversy - Inflation, Productivity and distribution- Fiscal policy: Effectiveness and

Problems. Social Accounting Matrix Framework - General Equilibrium Analysis- Neo -classical Macro Economics - Stochastic Macro Economics. Balance of Payment & Adjustment Policies - Foreign Exchange Policy- Foreign sector : Capital and Current Account. Impact of WTO on Indian Economy- Impact of IMF & IBRD policies on Indian Economy- Review of Macro Economic Policies in India.

AEC 603 ***Advanced Econometrics*** **(0+1)**

Practical

Review of classical regression model – review of hypothesis testing – restrictions on parameters – single equation techniques. Ordinary least squares – weighted least squares - generalized least squares –method of principal components – instrumental variables method - maximum likelihood method - errors in variables, non-linearity and specification tests – non spherical error terms. Estimation of multiple regression model - GLS estimation methods - testing mis-specification errors – Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probit models - comparing two regressions - ChowDummy variables - Qualitative and truncated dependent variables - limited dependent variables –LPM, probit and logit models, their multinomial extensions. Autoregressive distributed lag models – panel data fixed and random effects models and their extensions. Simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS.

AEC 604 ***Advanced Production Economics*** ***(*1+1)**

Theory

Agricultural production process- Relationship between farm planning and production economics- scope of agricultural production and planning methods/procedures in agro-economic research and planning. Production functions, components, assumptions, properties and their economic interpretation- concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance. Production relations- optimality. Commonly

used functional forms, nature, properties, limitations, estimation and interpretation-linear, Spillman, Cobb Douglas, quadratic, multiplicative (power) functional forms-Translog and Transcendental functional forms- CES, production functional forms- Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum- Economic optimum- determination of economic optimum with production function analysis, input use behavior. Decision making. Decision making with multiple inputs and outputs- Decision making with no risk- cost of wrong decisions. Cost curves. Duality of profit and cost functions- principles and derivation of demand and supply functions. Technology, input use and factor shares, effect of technology on input use. Decomposition analysis. Factor shares-estimation methods- Economic efficiency in agricultural production –technical, allocative and economic efficiency –measurement Yield gaps analysis-concepts and measurement. Risk and uncertainty in agriculture, incorporation of risk and uncertainty in decision-making –risk and uncertainty and input use level- risk programming. Economic analysis of risk mitigating measures, economics of Integrated farming system

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions- Derivation of demand and supply functions- Estimation of cost functions and interpretations- Estimation of factor shares from empirical functions estimated –Estimating production functions incorporation of technology –Estimation of efficiency measures- Stochastic, probabilistic and deterministic frontier production functions- Simulation models for agricultural production decisions.

AEC 605 ***Quantitative Development Policy Analysis*** ***(*1+1)**

Theory

Policy framework – goals, value, beliefs and welfare maximization. Market– Policy and State; State vs. Market – Failure of Policy, Failure of Markets, Rationale for Government Intervention. Role of Quantitative Policy Analysis. Demand

analysis for policymaking – Alternative approaches to demand analysis – Policy implications. Supply response – Alternative approaches to measurement of supply response – Nerlovian models of supply response – Policy implications. Household behaviour and policy analysis – Household models. Theory of public choice. Partial equilibrium analysis – Concept of reference prices – Price distortions – indicators and impact. Transaction costs – Implications for efficiency and productivity – Institutional solutions - Multi market approach to policy analysis. Social Accounting Matrices and multipliers –- Computable General quilibrium models to assess economy wide impact of policy changes.

Practical

Review of criteria for policy evaluation – Estimation of price elasticities – Review of estimation of complete demand systems – Estimation of Nerlovian supply Response model – Review of Household models – Specification and estimation of household models – Partial equilibrium analysis – Input–output table – Social Accounting Matrix – Construction of a SAM – computation of Multipliers – Multi Market Analysis – Review of Computable General Equilibrium Models.

AEC 606 ***Advanced Agricultural Marketing and Price Analysis*** **(1+1)**

Theory

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

etc. commodity exchanges - price discovery and risk management in commodity markets- Regulatory mechanism of futures trading. Lag operators and difference equations; stationary and stochastic processes; UNIT roots and cointegration; conditional heteroscedasticity: ARCH and GARCH models-forecast valuation; methods of forecasting. price indices and econometric estimation and simulation.

Practical

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

AEC 607 ***Advanced Natural Resource and Environmental Economics and Policy*** **(1+1)**

Theory

Stock and flow (dynamics) concepts of renewable and non-renewable resources. Growth curves of fishery and forest resources. The role of time preference in natural resource extraction and use. Simple two-period model of optimal extraction and use of renewable and non-renewable resources. Advanced models of optimal resource use – Static Vs. dynamic efficiency in natural resource extraction and use. Applications of dynamic programming and optimal control theory. Economics of groundwater use - optimal extraction of groundwater. Analytical and numerical solutions for optimal inter-temporal allocation of natural resources. Optimal harvesting of single rotation and multiple rotation forests. Optimal management of fishery. Property rights in natural resources and their implication for conservation and management of natural resources. Management of common property natural resources – Institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource. Resource scarcity – Natural resource degradation – Poverty and resource degradation – Natural resource accounting - Pricing and valuation of natural resources – Natural resources

policies related to water, forestry, land and bio-diversity. Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities - Optimum pollution under market imperfection and uncertainty – Private vs. Social cost of environmental pollution – Property rights, environment and development – Theory of environmental policy. Environmental cost benefit analysis - Environmental impact assessment techniques - Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare function and Pareto –optimality. Economic growth and environmental cost - Growth oriented economic policies and their environmental impacts - Population and environmental quality -poverty and environmental degradation – Sustainable development – Indicators of sustainable development – Issues in sustainable development. Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Urbanization and environment - Basic approaches to environmental policy (Tax, subsidy, pollution permits etc.) Green taxes - Political economy of environmental regulation and management. Transboundary environmental problems - Economics of global warming, Acid rain, species loss, climate change and emission trading - Environment, international trade and development. Global environmental agreements; Clean Development Mechanism and Payment for Ecosystem Service. .

Practical

Derivation of the fundamental equation of renewable resources-Estimation of growth curves and stock dynamics for fishery and forestry resources. Simple two period problem of optimal resource use – Numerical solution for simple two-period model of dynamic efficiency in natural resource extraction. Multi-period dynamic efficiency Optimal control Theory. Environmental Impact Assessment (EIA) techniques - Recreation demand models of environmental valuation - Contingent valuation techniques - Environmental Resource Accounting Techniques - Review of research works and case studies on natural resource extraction, air pollution and its impacts - forest environment and

wild life conservation - Green GNP and Green house insurance - Practical considerations and comparison of instruments of environmental policy - Non-point source pollution control methodology – Meta-analysis, economic valuation and environmental economics - Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment technology and the environment - Computable general equilibrium models for environmental economics and policy analysis.

AEC 608 ***Operations Research*** **(0+1)**

Practical

Introduction and nature of operations research. History of operations research, characteristics of operations research. Stages in development of operations research, project-formulation and components of a problem. Deterministic models, Linear programming and its applications. Transportation models, Dynamic programming. Constrained and unconstrained non-linear programming methods, multiple objective decision making. Stochastic models, Markov chains, Bayesian analysis. Theory of inventory management: Economic ordering quantity and related issues, maintenance and replacement problems Network flow problems. PERT and critical path methods. Queuing theory. Game theory-business games, Monte Carlo method, Simulations, Heuristic programming Application of OR techniques to agriculture. Numerical examples and case studies in the following OR problems. Formulation of OR problems and solving them using various steps. Application of linear programming and dynamic programming. Inventory problems, networks flow problems, PERT and critical path methods, queuing problems, stochastic and Markov chains, unconstrained and constrained non-linear programming models. Application of operations research to specific agricultural problems.

AEC 609 ***International Trade*** **(0+1)**

Practical

International and inter-regional economics; Free trade themes; Important arguments in favour of free trade; Reservations. The

Classical theory of international trade: Adam Smith's theory of absolute advantage. Ricardian theory of comparative advantage. Factors that lead to specialization and international trade. Gains from international trade; Resource allocation, welfare gain to individual country. General Equilibrium of international trade in closed and open economies. Foreign trade Multiplier: Effects of international trade on employment and income. Terms of Trade: Introductory analysis: meaning and importance; Net barter terms of trade; Gross barter terms of trade; Income terms of trade. Theory of protection:– Early arguments, valid arguments in favour of protection : non-economic and economic methods of protection-Tariffs, Quotas and subsidies, anti-dumping, anti-monopoy polices, state trading, Theory of customs: Union and economic integration, theories of foreign exchange rates. Balance of payment: disequilibrium and adjustment mechanism, devaluation as a method of correcting adverse balance of payment. Theory of international capital movement, international trade blocs & cooperation – trade conferences – General Agreement of Tariff & Trade, WTO, – IMF, IBRD, IDA and international debt of less developed economies. Trade, environment and public policy, economics of environmental policies in open economies, environment, international trade and competitiveness, Effects on the environment and welfare of liberalizing world trade, International economic integration and the environment, Sanitary and Phyto-Sanitary measures and their economics, India's foreign trade and direction – a special reference to agricultural exports, imports, structure, composition and direction of the trade.

AEC 610 ***Advanced Institutional Economics and Evolution of Economic Thought*** **(1+1)**

Theory

Old and New Institutional Economics - Institutional Economics Vs Neo- classical Economics. Definition of institutions – Distinction between institutions and organizations - Institutional evolution Institutional change and economic performance-national and international economic institutions. Transaction cost economics – Transaction costs and the allocation of resources. Transaction

costs and efficiency. Asymmetric information - Moral hazard and Principal-Agent problem. Free rider problem – path dependency – Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem, theory of Groups. Rent seeking – interest groups and policy formulation. Economic analysis of property rights- property rights regimes – private property – State Property - Common property Resources (CPRs) – public goods and club goods. Coase Theorem. Special features of institutional arrangements in agriculture. Transaction costs in agriculture , Case Studies. Theories of agrarian institutions - tenancy institutions. Approaches for the study of history of economic thought – Absolutist vs. Relativist approaches – Evolution of Economic Thought vs. Economic History. Ancient economic thought – medieval economic thought, mercantilism, physiocracy – Forerunners of Classical Political Economy. Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo) – Critics of Classical Thoughts-Socialist critics – Socialist and Marxian Economic Ideas – Austrian School of Thought – Origins of Formal Microeconomic Analysis – William Stanley Jevons, Cournot and Dupont.

Practical

Exercise on review of literatures, case studies and empirical analysis.

AEC 611 ***Advanced Agricultural Financial Management*** **(1+1)**

Theory

Nature and the process of financial management. Organisational areas of the firm. Time and managerial decisions. Capital and credit requirement in agriculture – assessment and estimation procedures. Agril. project planning – Project cycle. Techno-economic appraisal of investments in agriculture. Monitoring and evaluation of agriculture projects. Project evaluation techniques like Net Present Value, Benefit – Cost Ratio and Internal Rate of Return. Data needs for project evaluation. Inflation, risk in financial

planning. Financial leverage and farm growth. Cost of capital – explicit and implicit costs of equity and debt capital ; credit liquidity premium; optimal credit structure; liquidity management. Agricultural financing : Financing of marketing and processing activities. Role of crop insurance in agril. financial management. Regional disparities on agricultural financing – Techniques and estimation. Recent advances/changes in institutional credit policies and their impact on institutional agricultural lending. Research techniques in agril. financial management – Budgeting technique, cash flow analysis, regression analysis, profit function approach, principal component analysis, factor analysis, discriminant function analysis, cluster analysis, programming techniques.

Practical

Exercises on application of the principles/techniques covered in theory after generating the required data.

AGRICULTURAL ENTOMOLOGY

Course No.	Title	Credits
AET 601	Advanced Insect Systematics	1+2
AET 602	Immature Stages of Insects	1+1
AET 603	Advanced Insect Physiology	2+0
AET 604	Advanced Insect Ecology	1+1
AET 605	Insect Behaviour	1+1
AET 606	Recent Trends In Biological Control	1+1
AET 607	Advanced Insecticide Toxicology	1+1
AET 608	Advanced Host Plant Resistance	1+1
AET 609	Advanced Acarology	1+1
AET 610	Agricultural Ornithology	1+1
AET 611	Molecular Approaches In Entomological Research	1+1
AET 612	Advanced Integrated Pest Management	2+0
AET 613	Plant Biosecurity and Biosafety	2+0
AET 614	Ecology and Biology of Soil Invertebrates	1+1
AET 615	Forest Entomology–Ecology and Management	1+1
AET 616	Advances In Insect Pathology	1+1
AET 671	Qualifying Examination	3
AET 681	Seminar	4
AET 691	Research	28

AET 601 ***Advanced Insect Systematics*** **(1+2)**

Theory

Detailed study of three schools of classification- numerical, evolutionary and cladistics. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts and speciation processes and evidences. Zoogeography. 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. Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN- Ethics. Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, revisionary works, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular Taxonomy, barcoding species.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, 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 polarisation for developing cladograms and use of computer programmes to develop cladograms.

AET 602 ***Immature Stages of Insects*** **(1+1)**

Theory

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holo-metabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Types of immature stages; their collection, rearing and preservation. Identification of immature insects to orders and families, in endopterygote orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

AET 603 ***Advanced Insect Physiology*** **(2+0)**

Theory

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization. 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. Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms. Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

AET 604 ***Advanced Insect Ecology*** **(1+1)**

Theory

Characterisation 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. Insect Plant Interactions. Fig-fig wasp 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. Host seeking behaviour of parasitoids. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses. 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. 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.

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.

AET 605 ***Insect Behaviour*** ***(*1+1)**

Theory

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism. 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. Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Self organization and insect behaviour.Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, coevolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; 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.

AET 606 ***Recent Trends in Biological Control*** **(1+1)**

Theory

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations. Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices. Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural

enemies, survivorship analysis and ecological manipulations, large-scale production of biocontrol agents, bankable project preparation. Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

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

AET 607 *Advanced Insecticide Toxicology* (1+1)

Theory

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. 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. Joint action of insecticides; activation, synergism and potentiation. 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. Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards, and good agricultural practices.

Practical

Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects.

AET 608 *Advanced Host Plant Resistance* (1+1)

Theory

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

Practical

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

AET 609 *Advanced Acarology* (1+1)

Theory

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. Management of economical important species of mites in

agriculture, veterinary and public health; storage acarology. 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. Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- Identification, isolation and utilization.

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.*

AET 610 ***Agricultural Ornithology*** **(1+1)**

Theory

Status of agricultural ornithology in India, groups of birds associated with agro-ecosystems. Habitat associations of birds in both wet and dry agricultural systems. Association of birds with different cultivation practices and crop stages, their seasonality and succession. Pestiferous and beneficial birds associated with different crops, their general biology and ecology. Food and feeding habits of birds in crop fields. Nature of damage caused by birds in different crops. Foraging ecology of birds in agricultural fields. Birds affecting stored grains in houses and godowns. Beneficial role of birds in agriculture and attracting them to field. Use of bird excreta in agriculture. Management of bird pests in agriculture: physical, cultural, ecological and chemical methods.

Practical

Study of different groups of birds associated with agriculture, their morphology and field identification. Field visits to different agroecosystems. Study of bird associations with different crop

stages. Study of nesting and roosting habits of birds in agricultural habitats. Study of the feeding habits, nature and types of damage caused by birds in selected crops. Visits to godowns. Analysis and study of the use of bird excreta in agriculture at a bird sanctuary. Field visits to paddy growing command areas to study birds in crop fields. Assignments on assessing bird damage, estimation of populations, etc.

AET 611 ***Molecular Approaches in Entomological Research*** **(1+1)**

Theory

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

Practical

Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

AET 612 ***Advanced Integrated Pest Management*** **(2+0)**

Theory

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling. Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests. Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' realtime situations. 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.

AET 613 ***Plant Biosecurity and Biosafety*** **(2+0)**

Theory

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Bio-warfare, Emerging/resurgence of pests and diseases. 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. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

AET 614 ***Ecology and Biology of Soil Invertebrates*** **(1+1)**

Theory

History of soil biology. Advantages and disadvantages of soil and habitat for invertebrates. Role of soil physico-chemical properties on the distribution of soil invertebrates. Classification of soil invertebrates, habits and identification. Assessment of invertebrates population in soil and litter sampling and extraction methods. Biology, ecology and behaviour of soil invertebrates. Factors affecting distribution of soil invertebrates. Role of soil invertebrates in litter decomposition and sustainability. Inter-relationship among soil invertebrates and soil microbes. Impact of soil invertebrate activities on the soil properties. Effects of agricultural practices on the soil invertebrates. Invertebrates as bio-indicators of soil health.

Practical

Study of relation between physico-chemical properties of soils and soil invertebrate abundance and diversity. Identification of soil invertebrates, methods of soil and litter sampling for invertebrates. Methods of extraction of soil invertebrates. Role of invertebrates in litter decomposition. Effects of agro-chemicals on soil invertebrates. Assignments and small group projects.

AET 615 ***Forest Entomology–Ecology and Management*** **(1+1)**

Theory

Population dynamics of forest trees in relation to phytophagous insects. Effects of phytophagous insects in forest ecosystem. History and importance of forest entomology in India. Classification of forest insect pests. Factors responsible for outbreak of forest pests. Survey methodology for forest pests. Bio-ecology, nature of damage, distribution and management strategies of important insect pests of timber and fruit yielding species (Ber, Jack, Jamun) of natural forests and plantations (Teak, *Ailanthus,* Neem, *Eucalyptus*, Subabul, Bamboo, Sal, *Terminalia, Dalbergia, Albizia, Casuarina, Pterocarpus, Acacia* sp., Sandal, *Butea, Pongamia, Deodar,* etc.) Timber pests and their management. Insects induced deformities, malformations and plant galls in forest trees. Non insect pests of

forest trees. Infestation of forest seeds by insect pests. Principles and concepts. Forest pest management – silvicultural control, biological control, microbial control and IPM.

Practical

Study of Immature stages of insects of economic importance. Insect orders and families. Study of insect damage and sign categories. Identification of immatures and adult stages of important insect pests of timber and fruit yielding species (Ber, Jamun, jack) of natural forests and plantations (Teak, *Ailanthus*, Neem, Bamboo, Subabul, *Eucalyptus*, *Casuarina*, *Terminalia*, *Dalbergia*, *Albizia*, Sandal, *Pongamia*, etc.). Study of timber pests, Non-Insect pests and forest nursery pests. Each student has to collect and submit 50 insect pest species of forest plants/trees. Assignments and small group projects.

AET 616 ***Advances in Insect Pathology*** **(1+1)**

Theory

Scope and current status of insect pathology, Virulence, Infection and Epizootiology, Resistance and immunity, Infection and epizootiology, symptamatology and pathologies of diseases in insects caused by Bacteria, Fungi, Viruses, Protozoa, rickettssia, spiroplasma and nematodes. Defense mechanism in insects to entomopathogens. Diseases of beneficial insects, Interactions between Entomopathogens and insects, microbial pesticides, Genetic improvement of entomopathogens. Use of biotechnological tools in insect pathology. Requirements for registering microbial pesticides.

Practical

Study of different diseases of insects caused by fungi, bacteria and viruses. Using keys for identification of micro-organisms infesting insects. Study of mass multiplication techniques. Study of different diseases of honeybee and silkworm.

AGRICULTURAL EXTENSION

Course No.	Title	Credits
AEX 601	Advances in Agricultural Extension	1+1
AEX 602	Advanced Designs and Techniques in Social Science Research	1+1
AEX 603	Advances in Training Technology	1+1
AEX 604	Organizational Development	1+1
AEX 605	Advanced Instructional Technology	1+1
AEX 606	Theory Constructions in Social Sciences	2+0
AEX 607	Advanced Management Techniques	1+1
AEX 608	Media Management	1+1
AEX 609	Transfer of Technology in Agriculture	1+1
AEX 671	Qualifying Examination	3
AEX 681	Seminar	4
AEX 691	Research	38

AEX 601 ***Advances In Agricultural Extension*** **(1+1)**

Theory

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS. Cyber Extension - Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market – Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder's analysis in Extension. Main streaming gender in Extension - Issues

and Prospects. Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension. Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

Practical

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

AEX 602 ***Advanced Designs and Techniques in Social Science Research*** **(1+1)**

Theory

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

Practical

Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques. Content analysis,

case studies. Practicing participatory tools and techniques. Hands on experience on Computer Preparation and Data Collection instruments, review of previous studies.

AEX 603 ***Advances in Training Technology*** **(1+1)**

Theory

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

Practical

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

AEX 604 ***Organizational Development*** **(1+1)**

Theory

Introduction to organizations: Concept and Characteristics of organizations, Organizational Behvaiour - Context and concept - levels of organizations - formal and informal organizations, Theories

of organizations: Nature of organizational theory - classical theories - features of Bureaucracy - administrative theory and Scientific management - Neo-classical theories - the human relations movement - modern theory.Systems approach to study organization needs and motives - Attitude, values and ethical behaviour - alienation and work - work motivation - communication and interpersonal behaviour - organization communication - leadership behaviour - decision making, problem solving techniques - organizational climate - change proneness and resistance to change, Organizational change, Organizational structure - Process in organizing - Dimension of Motivation Climate. Departmentation - Span of Management - Delegation of authority - Centralization and decentralization - line and staff organization – functional organization - divisonalisation - Project organization - Matrix organization - free form organization - top management structure. Individual behaviour in organization. Fundamentals of Human relations and Organizational behaviour, Groups and teams - Organisational culture and performance. Dynamics of Organization behaviour - leadership conflict situations and inter group behavior- Organisational Development – Factors affecting organization effectiveness. Creativity, leadership, motivation and organization development.

Practical

Analysis of organization in terms of process - attitudes and values, motivation, leadership. Simulation exercises on problem-solving - Study of organizational climate in different organizations. Study of organizational structure of development departments, Study of departmentalization, span of control delegation of authority, decisions making patterns, Study of individual and group behaviour at work in an organization. Conflicts and their management in an organization. Comparative study of functional and non-functional organsiations and drawing factors for organizational effectiveness.

AEX 605 ***Advanced Instructional Technology*** **(1+1)**

Theory

Concepts in Instructional Technology, Scope of Instructional Technology. History of agricultural education in India. Guidelines for curriculum development in Agricultural Universities. Curriculum

design development. Course outline, Lesson plans for theory and practicals. Teaching and learning styles. Theories of learning. Cognitive levels. Instructional Course Objective. Motivation of students. Instructional Methods. Experiential learning cycle. Innovative Instructional Aids. Computer Assisted Instruction. Programmed instruction technique. Team Teaching. E-Learning, Art of Effective Communication. Distance education. Student evaluation - Question Bank. Appraisal of Teacher Performance. Review of research in Instructional Technology.

Practical

Formulation of instructional Course Objective. Development and presentation of course outlines. Preparation & presentation of lesson plans for theory & practical with CAI design. Preparation of innovative low cost instructional aids. Development of model question bank. Preparation of schedule for teacher evaluation. Visit to Distance Education centre. Study of research reviews and Presentation of reports.

AEX 606 ***Theory Constructions in Social Sciences*** **(2+0)**

Theory

Importance of theory constructions in social science. Theory: Meaning, elements, Ideal Criteria, Functions, Types. Definitions: Meaning, types and Rules. Generalizations: Meaning, Classification. Relationship: Meaning Types. Terminologies used in theory constructions: Axiom, Postulate, Proposition, Theorem, Fact, Concept, Construct, Probability and Measurement Basic Derived. Steps in theory building - Axiomatic Techniques, Historical approaches. Scientific application; Theoretical concept in Social Sciences. Test of Theory: Applying appropriate statistical tests.

AEX 607 ***Advanced Management Techniques*** **(1+1)**

Theory

Management Information System (MIS): Basic concepts, types of information needed at various levels, design of MIS in an agricultural extension organization. Scope for computerization, system alternatives and Evaluation. Implementation, operation and

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

Practical

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

AEX 608 ***Media Management*** **(1+1)**

Theory

Media Management – Introduction, Definition, Principles and Significance of Management. Media Ownership patterns in India – Proprietorship, Partnership, private Ltd, Public companies, Trusts, Co-operatives, Religious Institutions (Societies) & Franchisees (Chains). Marketing Function – Product, Price, and Placement & Promotions. Mass Communication – Meaning, Concept, Definition and Theories of Mass Communication. The Mass Media – History, functions, uses and Theories of Media. Journalism – Meaning, definition, Scope, functions and different types of Journalism. Journalism as communication tool. Farm Journalism – meaning and Developments in Farm Journalism in India. Different problems with

Farm Journalism. Print Media – History, the role of the press, news, Types of News, electronics of News and Sources of News, the making of newspaper & magazines, press codes and ethics, Media Laws. News story – Principles of writing, structure a news story, procedure in writing the news story and the elements of style. Success stories & feature articles – writing for success & feature articles, Types of Feature articles. Information materials – Types of information materials and user. Techniques in book Publishing. Editing – Principles, Tools & Techniques and art of Proof Reading – Techniques, Measuring Readability of writing. Electronic Media- Role and Importance of Radio -History, Radio Role in TOT, writing and presentation techniques, Different Programmes of Farm Broadcast, developing content for farm broadcast, Role of FM Radio in Agriculture, Ethics of Broadcasting, Broadcasting Policy and code. Community Radio – Concept, meaning, role in TOT, Cases of Community radio. Television – History - Role in TOT , Fundamentals of Television Production, Techniques of Script writing for TV, Visual Thinking, language & Style, Farm Telecast programmes, cable and satellite TV and their impact, Ethics of Telecasting, policy and code. Video Production Technology – Potential and its utilization, Typology of farm Video production, Types of Video Production and equipment used in the production, Procedure or Technique of video production. Cassette Technology – Role in TOT, Techniques of production of cassettes for the farming community. Traditional Media – Role of Folk Media in TOT and integration with electronic media. Advances in communication Technology – Management of Agricultural Information System (MAIS). Use of computers in Agriculture – Application of IT in Agriculture. Use of Modern Communication Medium- Electronic Video, Teletext, tele conference, Computer assisted instruction, Video conferencing, - Features, Advantages, Limitations and risk factory involved in New Media. Designing and developing of communication and media strategy for developmental programmes. Online journalism scope & importance.

Practical

Exercise on Writing for Print Media – Writing News / Success Stories / Feature articles for different topics related to Agriculture

& allied fields. Exercise of editing & proof reading the Farm News for News papers – different types of intro and leads. Exercise of Writing for Radio, TV, Preparation of story board for farm Video Production – Script writing for Radio and T.V. Visit to media management organizations for studying the principles, procedures and processes in managing the media. Participation and Interaction through video conference. Developing communication & Media Strategy for selected developmental programme / activity.

AEX 609 ***Transfer of Technology in Agriculture*** **(1+1)**

Theory

Technology - Meaning and Concepts - Appropriate technology, transfer of technology - meaning and concepts. Systems of transfer of technology - Knowledge Generating System (KGS) - Knowledge Disseminating System (KDS) - Knowledge Consuming System (KCS) - Input Supplying Agencies System (ISAS). Appropriateness of communication media in the system of technology transfer. New communication strategy for transfer and adoption of Agricultural technology. Extension training in transfer of technology. Analysis. Constraints in Transfer of Technology, agencies or departments involved in TOT. Extension professional in TOT. Attributes of Technology and its Relation in TOT process. TOT to resource poor farmers. Role of Key communicators or local leaders in TOT. Private and Public partnership in TOT.

Practical

Analysis of Transferred technology. Analysis of knowledge generation and consuming systems. Formulation of communication strategies, Study of attributes of selected fast spreading technologies and slow technologies, study of constraints in TOT, Visit to TOT centres of ICAR and SAU, Identification of key communicators, Case studies of Public-Private Partnerships, Visits to the print and electronic media centres to study their role in TOT.

AGRICULTURAL MICROBIOLOGY

Course No.	Title	Credits
AMB 601	Advances in Fermentation	1+1
AMB 602	Advanced Microbial Physiology	1+1
AMB 603	Regulation of Microbial Biosynthesis	1+1
AMB 604	Current Topics in Soil Microbiology	1+1
AMB 605	Plant-Microbe Interactions	2+1
AMB 606	Microorganisms in Biofuels and Bioenergy Production	1+1
AMB 607	Microbial Management of Organic Wastes and Xenobiotics	1+1
AMB 671	Qualifying Examination	3
AMB 681	Seminar	4
AMB 691	Research	38

AMB 601 ***Advances in Fermentation*** **(1+1)**

Theory

An overview of fermentation - current status of fermentation industry. Fermentor design, high performance bioreactors, mass and energy transfer in bioreactors. Instrumentation and control in fermentors – on line measurement systems, computer application. Media for microbial fermentation; Criteria in media formulation. An overview of downstream processing. New strategies for isolation of industrially important microbes and their genetic manipulations; Microbial production of health care products. Antibiotic fermentation research; steroid transformation. Recent developments on production of primary and secondary metabolites, Treatment of biological wastes, microbial inoculants and enzymes for waste treatment. Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries and topics of current interest in fermentations.

Practical

Industrially important microbes and their genetic manipulations, Fermentation by improved strains of yeast for production of alcohol and beer, Microbial production of important antibiotics, enzymes and organic acids, Bioremediation of industrial effluents.

AMB 602 ***Advanced Microbial Physiology*** **(1+1)**

Theory

Origin, evolution, structure, function and molecular aspects of various cell components. Differentiation in bacteria, slime molds, yeasts. Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria. Topics of current interest in molecular microbiology.

Practical

Study of prokaryotic cell structure. Determination of stress protein with particular reference to heat shock proteins. Phylogenictic analysis of prokaryotes. Study of slime and extra cellular proteins.

AMB 603 ***Regulation of Microbial Biosynthesis*** **(1+1)**

Theory

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways. Ribosomal RNA and protein regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression. Oxidative stress control. Fermentative and respiratory regulatory pathways. Regulation of cell cycle. Lytic and lysogenic cascade. Global nitrogen control and regulation of nitrogen fixation and other recent topics of regulatory systems of current interest.

Practical

Diauxic growth in bacteria. Determination of growth yield of bacteria. Chemotaxis. Polymerase Chain Reaction; Global Control Mechanism.

AMB 604 ***Current Topics in Soil Microbiology*** **(1+1)**

Theory

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Microbial successions and transformation of organic matter; Role of microorganisms in soil fertility. Bioremediation of polluted soils; Biological control of Soil borne Plant Pathogens. Other topics of current interest.

Practical

Activities of soil enzymes; Study of chemoautotrophic bacteria, Heterotrophic nitrification; Microbial transformation of xenobiotics. Study of microbial successions.

AMB 605 ***Plant-microbe Interactions*** **(2+1)**

Theory

Different interfaces of interactions - Plant-microbe, microbe-microbe, soil microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal), associative, endophytic and pathogenic interactions. Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Flow of signals in response to different carbon or other substrates and signal recognition. Methodology/ resources to study plant-microbe interaction, biosensors, metabolic profiling, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces. Plant and microbial gene expression and signal exchange. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

Practical

Cultivation of various diazotrophs in laboratory. Microbiological analysis of rhizosphere soil samples of selected plant species and determination of R:S ratio. Isolation and identification of nitrogen fixing microorganisms and mycorrhizal fungi from selected ecosystems. Determination of efficiency of nitrogen fixing systems. Most probable number technique to determine the number of mycorrhizal infection units. Axenic culture of vesicular arbuscular mycorrhizal fungi.

AMB 606 ***Microorganisms in Biofuels and Bioenergy Production*** **(1+1)**

Theory

Methane production: Microbial consortia and biological aspects of methane fermentation: Hydrolysis and acidogenesis; Acetogenesis and dehydrogenation; Methanogenesis Development in bioreactor technology; Upflow anaerobic sludge blanket (UASB); Upflow anaerobic filter process (UAFP); Anaerobic fluidized – bed reactor (AFBR); Two-phase methane fermentation processes. Bioethanol from biomass: Saccharification of cellulosic waste materials: Pre-treatment of cellulosic waste. Saccharification; Recovery and re-use of cellulose; Screening of cellulose – producing microorganisms. Microbial-based biofuels: Microbial bioreactors producing H2 for conventional fuel. Integrated microbial – based biofuels producing electrochemically active metabolites. Oil production: Oil substitutes from biomass. Microalgae as biological sources of lipids and hydrocarbons. Future prospects in mechanisms of crude oil formation by natural phenomena.

Practical

Microbial consortia and biological aspects of methane fermentation. Utilization of organic materials for hydrogen production. Saccharification of cellulosic waste materials like corn, cotton wastes, crop residues. Concentration of sugar solutions using reverse osmosis membrane technology. Use of immobilized yeast cells in alcohol fermentations. Biophotolysis of water by microalgae and cyanobacteria. Cultivation of microalgae as biological sources of lipids and hydrocarbons.

AMB 607 ***Microbial Management of Organic Wastes and Xenobiotics*** **(1+1)**

Theory

Organic wastes in tropical, temperate and forest ecosystems. Aerobic and anaerobic decomposition - mechanism and factors influencing degradation. Management of farm waste – methods of composting, microbiology of composting, factors influencing decomposition. Liquid waste management – sewage treatment

process, recycling of sewage water. Treatment of effluents from paper, sugar, distillery & tannery industries. Urban solid waste management – composition of wastes; microbial degradation strategies and enrichment technology – Vermi-composting, sanitary landfill method. Production of single cell protein & mushroom. Biodegradation of xenobiotics - Hydrocarbons including petroleum hydrocarbons; Halogenated aliphatic compounds;Halogenated aromatic compounds; Non-chlorinated pesticides and herbicides; Explosive chemicals, TNT, TDX; Genetic basis of biodegradation – enhancing bacterial degradation genes through molecular biology. Application of biodegradation and bioremediation - Concept of bioremediation. Soil inoculation with degrading bacteria; Monitoring bacteria introduced into the soil.

Practical

Qualitative and quantitative enumeration of microorganisms in organic wastes. Study of cellulolytic and lignolytic microbes. Microbial succession during composting. Production of single cell protein & mushroom. Preparation of Vermi compost. Development of enrichment cultures for degradation of pesticides, Degradation of pesticides in Soil. Extraction of Pesticides from soil samples. Separation of metabolites by TLC.

AGRONOMY

Course No.	Title	Credits
AGR 601	Current Trends in Agronomy	3+0
AGR 602	Crop Ecology	2+0
AGR 603	Crop Production and System Modeling	2+1
AGR 604	Advances in Crop Growth and Productivity	2+1
AGR 605	Irrigation Management	2+1
AGR 606	Advances in Weed Management	2+0
AGR 607	Integrated Farming Systems	2+0
AGR 608	Soil Conservation and Watershed Management	2+1
AGR 609	Stress Crop Production	1+1
AGR 671	Qualifying Examination	3
AGR 681	Seminar	4
AGR 691	Research	38

AGR 601 ***Current Trends in Agronomy*** **(3+0)**

Theory

Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship. Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures. Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy. GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc. Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

AGR 602 ***Crop Ecology*** **(2+0)**

Theory

Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply Agro-ecological regions and agro-climatic zones of India and Karnataka. Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept. Ecological factors affecting crop production. Physiological response of crop plants to light, temperature, CO_2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production. Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production. Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop, selection and management.

AGR 603 ***Crop Production and System Modeling*** **(2+1)**

Theory

Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams. Elementary models for crop growth based on basic methods of classical growth analysis. Crop modeling methods for crop-weather interaction, climate change and variability components. Potential production: leaf and canopy CO_2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops. Production by moisture availability, potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

Practical

Simulation of elementary models for crop growth, Simulation of potential production, Simulation with limitations of water and nutrient management options, Sensitivity analysis using different climatic years and crop management practices

AGR 604 ***Advances in Crop Growth and Productivity*** **(2+1)**

Theory

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; differences in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation. 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. 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. Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

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

AGR 605 ***Irrigation Management*** **(2+1)**

Theory

Water resources of India, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth. Irrigation projects; irrigation needs**,** Interlinking of rivers and their prospectus in India, Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity. Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops. Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of Irrigation and farming systems affecting irrigation management. Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies. Water production functions, minimizing energy requirement, crop water modelling. Land suitability for irrigation, land irrigability classification; integrated water management in command area, institutions of water management in commands, farmer's participation in command areas; irrigation legislation. irrigation management information systems, irrigation policy in India

Practical

Determination of water infiltration characteristics and water holding capacity of soil profiles. Study of automated irrigation. Systems. Moisture extraction pattern of crops. Planning for the layout of Sprinkler / drip irrigation systems for closer & wider spaced crops, Consumptive use, water requirement of a given cropping pattern for ORP in water management with reference to command area. optimum/variable productivity. Crop planning at the farm and project level. Agronomic evaluation of irrigation projects, case studies.

AGR 606 ***Advances in Weed Management*** **(2+0)**

Theory

Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects. Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them. Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants. Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides. Development of transgenic herbicide resistant crops; herbicide development, registration procedures. Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical herbicide bioassays.

AGR 607 ***Integrated Farming Systems*** **(2+0)**

Theory

Farming systems; definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialisation, water supply; enterprises in farming systems. Concept of sustainability in farming systems; efficient farming systems; natural resources – identification and management. Farming system approach, concept of integration – Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems; eco-physiological approaches to farming systems. Simulation models for farming systems; nutrient recycling in farming systems – sustainability , input rationalisation; preparation of different farming systems models; New concepts and approaches of farming systems and cropping systems. Farming system approach for sustainability; Energy concept in farming systems- evaluation based on energy relations. Case studies of different farming systems.

AGR 608 ***Soil Conservation and Watershed Management*** **(2+1)**

Theory

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion. Soil conservation: definition, methods of soil conservation in arable lands, agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; Vegetative measures of soil conservation, role of grasses and pastures in soil conservation; wind breaks and shelter belts. Watershed management: definition, objectives, concepts, approach, components, watershed identification, delineation, prioritization, characterization watershed planning, steps in implementation of watershed; development of cropping systems for watershed areas. Land use capability classification, Treatment of non-arable lands, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout. Drainage line treatments; Social mobilization and community organization in watersheds, participatory watershed development, livelihood activities for landless labourers in watershed. Rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion

Practical

Field studies of different soil conservation measures in Arable lands -Non arable lands- Drainage lines- Run-off and soil loss measurements, Laying out run-off plot and deciding treatments, Identification of different grasses and trees for soil conservation, Watershed delineation and Action plan preparations using GIS and remote sensing, Visit to a soil conservation research centre, demonstration and training centre, Roof top Rainwater harvesting

AGR 609 ***Stress Crop Production*** **(1+1)**

Theory

Stress and strain terminology; nature and stress injury and resistance; causes of stress. Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling

injuries and resistance in plants, practical ways to overcome the effect of low temperature stress through soil and crop manipulations. 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. Water deficit stress: meaning of plant water deficit 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. 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. 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. Other stresses-Hailstorm and its effect on crop growth, ways to overcome the stress. Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance. Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

Determination of electrical conductivity of plant cell sap, Determination of osmotic potential and tissue water potential, Measurement of transpiration rate, Measurement of stomatal frequency, Growing of plants in sand culture 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.

CROP PHYSIOLOGY

Course No.	Title	Credits
CPH 601	Functional Genomics and Genes Associated with a Few Physiological Processes	2+0
CPH 602	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0
CPH 603	Molecular Approaches for Improving Physiological Traits	2+1
CPH 604	Advanced Techniques in Plant Physiology	0+2
CPH 605	Climate Change and Crop Growth	2+0
CPH 606	Post Harvest Physiology	2+0
CPH 607	Weed Physiology and Herbicide Action	1+1
CPH 608	Physiological Aspects of Seed Growth and Development	1+1
CPH 609	Metabolites and Bioprospecting	2+0
CPH 610	Molecular Physiology of Mineral Nutrient Acquisition, Transport and Utilization	1+1
CPH 671	Qualifying Examination	3
CPH 681	Seminar	4
CPH 691	Research	38

CPH 601 ***Functional Genomics and Genes Associated with a Few Physiological Processes*** **(2+0)**

Theory

Gene discovery: Finding genes in complex plant system, Constructing gene-enriched plant genomic libraries, In Silico prediction of plant gene function, Quantitative Trait Locus analysis as a gene discovery tool. Genetic tools for plant development-Understanding the importance of mutants in unraveling the physiological processes – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for gene discovery, High-Throughput TAIL-PCR as a tool to identify DNA flanking insertions,

High-Throughput TILLING for functional genomics. Gene knock out approaches: Antisense technology, Virus Induced Gene Silencing (VIGS), Custom Knock-outs with Hair-pin RNA-mediated gene silencing and other Silencing tools, Complementation studies, DNA micro arrays. Gene over expression approaches: Vector construction for geneo Overexpression as a tool to elucidate gene function; Transient expression, Transgenics. Proteomics: Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study protein –protein interaction to study gene functions, Proteomics as a functional genomics tool, Crystallographic and NMR approaches to determine protein structures. Functional characterization of genes associated with important cellular processes influencing crop growth and development. Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

CPH 602 ***Signal Perceptions and Transduction and Regulation of Physiological Processes*** **(2+0)**

Theory

General aspects: Introduction to signaling-Long range (diffusible) signaling and short range (contact) signaling. Components of signaling- Upstream components: receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Down stream components: G. proteins-second messengers-Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor). Hormone signaling: Hormone binding receptors-Transduction process. Effector molecules and gene expression. Specific signaling pathways of Auxins, Cytokiniln, Gibberllins, Ethylene, ABA, Brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants. Light signaling: Perception of light-pigments involved-activation of phytochrome/cryptochrome (study of mutants). Light signal transduction- Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

Abiotic stress signaling: Sensing of environmental factors (Temperature- Osmoticum-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses. Cross talk between signaling pathways. Signal perception and transduction in plant defense responses: Role of salicylic acid and active oxygen species. Signaling cascade during leaf senescence, abscission, flowering and tuberisation. Transcription factor as signaling regulatory tools for improving growth processes-Case studies: Tbi- lateral branch development, Shi 4- grain shattering, GA1- Dwarfing.MADS, KNOX- flowering development, HAT 4-Shade development, AP2-EREBP- biotic/abiotic stresses.

CPH 603 ***Molecular Approaches for Improving Physiological Traits*** **(2+1)**

Theory

Importance of molecular breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding. Physiological traits with relevance to growth, development, abiotic stress tolerance, nutrient acquisition. Approaches for accurate phenotyping of large germplasm accessions and/or mapping populations. The advantages of "Trait based" breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of dominant and co-dominant marker systems. Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure. Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc. Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining. Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such

as stress tolerance) and their potential benefits in transgenic crops. Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes. Transformation of crop plants- *Agrobacterium* and use of other organisms for transformation- particle gun transformation and other methods. Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events. Evaluation of transgenics on basis of empirical/physiological/ biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements. Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

Practical

Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Statistical approaches to assess genetic variability, heritability and other parameters, phylogenic analysis, principal component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis, molecular biology - genomic/plasmid DNA isolation, RNAisolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system,Crop transformation - *Agrobacterium* mediated transformation (inplanta & invitro), particle-gun transformation, Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

CPH 604 *Advanced Techniques in Plant Physiology* (0+2)

Practical

Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO_2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes. Radio active isotopes in plant biology. Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes. Methods to phenotype germplasm for specific physiological traits. Quantification of mineral nutrients using advanced instruments like AAS & ICP. Techniques in plant transformation & analysis of transgenic plants. Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLS. Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phospho-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

CPH 605 *Climate Change and Crop Growth* (2+0)

Theory

History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability. Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth. Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply. Approaches to mitigate climate change through studies on plant responses.Direct and indirect effects of climate change on plant processes –

phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield. Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments. International conventions and global initiatives on Carbon sequestration, carbon trading.

CPH 606 ***Post Harvest Physiology*** **(2+0)**

Theory

Physiological changes during senescence and ripening. Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds. Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products. Functional and ultrastructural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening. Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action. Post harvest changes in seed and tubers biochemical constituent's quality parameters. Effect of environmental factors on post harvest changes in seed and tubers. Biotechnological approaches to manipulate ethylene biosynthesis and action. Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits. Uses of GM crops and ecological risk assessment.

CPH 607 ***Weed Physiology and Herbicide Action*** **(1+1)**

Theory

Weed and crop competition, and physiological and molecular aspects of herbicides. Weed biology, ecology and physiology. Weed and crop competition, allelochemicals, their nature and impact. Weed-seed physiology. Classification of herbicides and selectivity. Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides. Environmental and plant factors influencing entry, uptake and translocation of herbicides. Classification and

chemistry of common herbicides. Physiological, biochemical and molecular mechanism of action of different groups of herbicides; ACC synthase inhibitors, ALS inhibitors, Mitotic inhibitors, Cellulose biosynthesis inhibitors, Inhibitors of fatty acid biosynthesis, inhibitors of Photosynthesis, Auxinic Herbicides, New herbicides, Metabolic pathway of herbicide degradation in plants and soil. Herbicide adjuvants and their classification. Molecular mechanism of action of herbicide synergists and antagonists. Physiological and molecular mechanism of herbicide selectivity. Herbicide resistant crops; transgenic & tissue culture approaches to develop herbicide tolerant varieties

Practical

Adjuvants and their effect on spray droplets, chemical entry and transport. Determination of physiological and biochemical processes like photosynthesis, respiration, cell division, protein & fatty acid synthesis, membrane permeability as affected by herbicides. Quantification of pigment levels in leaves, specific enzyme activities affected by herbicides. Demonstration of translocating type of herbicides by radio labeling studies.

CPH 608 ***Physiological Aspects of Seed Growth and Development*** **(1+1)**

Theory

Seed germination, dormancy and physiological processes involved in regulation of seed development. Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development. Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion. Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats

in seeds and their biosynthesis. Seed respiration, mitochondrial activity, Seed ageing, mobilization of stored resource in seeds, chemistry of oxidation of starch, proteins and fats, utilization of breakdown products by embryonic axis. Control processes in mobilization of stored resources, Role of embryonic axes, gibberllin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins. Seed viability, physiology and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

Practical

Determination of seed storage proteins, Sink drawing ability of ovules, Empty ovule technique, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced aamylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds, Seed respiration rates, Seed viability losses through membrane leakage studies.

CPH 609 ***Metabolites and Bioprospecting*** ***(*2+0)**

Theory

Introduction of Bioprospecting – What is Bioprospecting? Classical examples of Bioprospecting, Potential value of Bioprospecting, status of bioprospecting in India. Approaches to Bioprospecting – 1. Random search 2. Algorithm based search a) Using indigenous knowledge b) Ecological based knowledge c) Evolutionary based knowledge d) Phylogenetic approach. Bioprospecting for known and unknown metabolites – Case studies. Databases and drug discovery-NAPRALERT, NCl and CDRl databases. Molecular markers in bioprospecting for known metabolites – microsatellites, AFLP; SNP's etc. Biosynthesis of secondary metabolites and metabolic engineering – secondary metabolitie pathways, rate limiting steps, over-expression systems etc. Using GIS based technology to predict species distribution for

bioprospecting –DIVA-GlS, GARP models. Evolutionary significance of plant chemical diversity and chemotaxanomy lPR issues and trade related issues in Bioprospecting – CBD, TRlPS, lPR's Valuation of biodiversity hotspots for bioprospecting –Western Ghats, Eastern Himalayas. Valuation techniques. Potential for bioprospecting in India – Medicinal plant diversity, indigenous knowledge, human resource. Traditional Knowledge and practice and its role in bioprospecting. Strategic plans for bioprospecting with reference to global scenario. Laboratory tools and techniques in bioprospecting-Bioassays, Chemical profiling through chromatographic techniques, molecular characterization using molecular markers. in-vivo and in-vitro protocols for multiplication and production of economically important metabolites-hairy roots, suspension cultures, micropropogation etc. Role of industry, academic institution collaboration in accelerating research in bioprospecting.

CPH 610 ***Molecular Physiology of Mineral Nutrient*** **(1+1)**
Acquisition, Transport and Utilization

Theory

Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological and chemical reactions influencing nutrient availability near the root system. Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity. Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for nitrate, phosphate, potassium and other nutrients. Multiple transporters for a single ion and their functional regulation. Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels. Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, examples of phosphorous, iron and zinc efficient crop varieties. Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practicals

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities and macro molecules. Recent techniques and instruments for determining nutrient levels in plants. Screening techniques for evaluation of nutrient efficiency. Molecular techniques-expression of specific transcripts under nutrient deficient or sufficient conditions.

FOOD SCIENCE AND NUTRITION

Course No.	Title	Credits
FSN 601	Advances in Carbohydrates, Proteins and Lipids	1+1
FSN 602	Advances in Vitamins and Hormones	2+0
FSN 603	Minerals in Human Nutrition	1+1
FSN 604	Advances in Food Science and Technology	1+1
FSN 605	Advances in Energy Metabolism	1+0
FSN 606	Nutrition and Agriculture Interface	1+0
FSN 607	Nutrition in Emergencies	1+0
FSN 608	Application of Biotechnology in Foods and Nutrition	2+0
FSN 609	Global Nutritional Problems	1+0
FSN 610	Maternal and Child Nutrition	1+1
FSN 671	Qualifying Examination	3
FSN 681	Seminar	4
FSN 691	Research	38

FSN 601 ***Advances in Carbohydrates, Proteins and Lipids*** **(1+1)**

Theory

Carbohydrates, proteins and lipids-their digestion, absorption, metabolism. Inborn errors of metabolism. Metabolic disorders-diabetes, dental caries, obesity, atherosclerosis, hyperlipidemia and hypertension.Glucose homeostasis determined by insulin/glycogen ratio; carbohydrates free diet and its metabolic consequences; glycemic index; dietary fiber- its definition, composition, classification, functions and role in various physiological disorders. Classification of protein, new discoveries in protein and their functions such as protein in Immune system, as lubricants, biological buffers and carriers, evaluation of protein quality: in vitro and in vivo methods,

animal and human bioassays: amino acid pool, protein turnover in man with special reference to body size, age and various nutrition and pathological conditions, regulation of proteins, requirements; novel food sources of protein. Effect of insulin, corticosteroids, thyroids, androgen and growth hormone on protein metabolism, inheritable disorders of amino acid metabolism of protein; effect of dietary protein on cardiovascular disease and cholesterol metabolism, adaptation of body to low intake of energy and protein. Estimation of body fat; lipoproteins and hyper lipoproteinemia; hypolipidemic action of PUFA omega-3 fatty acids and oxidation products of cholesterol; lipids and cancer; fish oils in health and disease; oxidative products of cholesterol. Disturbance in lipid metabolism; role of a diet in cardiovascular disorders; high blood cholesterol – causes, prevention and treatment; hypolipidemic action of rice bran, oat, barley and legumes.

Practical

Assessment of protien quality; project work related to metabolic disorders of proximate principles; blood analysis in relation to NCD (Non Communicable Diseases) and estimation of amylase and protease inhibitors in foods.

FSN 602 ***Advances in Vitamins and Hormones*** **(2+0)**

Theory

General definition and history of vitamins and hormones; cause of vitamin deficiencies in India. Chronology, chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations, Nutritional requirements, methods of assay. Interaction with other nutrients, antagonists and analogues of vitamins, Hypervitaminosis of water and fat soluble vitamins; vitamin fortification and supplementation; endocrine and exocrine secretion of hormones; organs of secretion, metabolism, mechanism of action, regulation and sites of action, biological effects and interaction. Assessment of vitamin status of population; antioxidants and their relationship with aging, cancer and other metabolic disorders.

FSN 603 ***Minerals in Human Nutrition*** **(1+1)**

Theory

General definition and history of minerals; causes of macro and micro mineral deficiencies in India. Chronology, chemistry, distribution, functions, absorption, transport, metabolism, deficiency manifestations. Nutritional requirements, methods of assay of all the minerals. Interactions of minerals with other nutrients, antagonists and analogues of minerals. Assessment of mineral status of population, mineral fortification and supplementation; major mineral pollutants- their harmful effect on health; mutagenicity, carcinogenicity, heavy metal toxicity. Use of mineral isotopes/ tracers in nutritional studies. Metaloenzymes; antioxidants and their relationship with aging, cancer and other metabolic disorders. Heavy metal toxicity; trace minerals, their chronology, chemistry, distribution, functions, absorption, metabolism, requirements, deficiency manifestation and interaction.

Practical

Assessment of antioxidants in foods; Project to combat micro nutrient deficiencies- Vulnerable sections, Groups with special needs.

FSN 604 ***Advances in Food Science and Technology*** **(1+1)**

Theory

Recent advances in the field of carbohydrates, lipids, proteins, vitamins and minerals in relation to human nutrition. Nutrogenomics, incorporating genetics into dietary guidance. Recent advances in the field of food analysis and food fortification. Foods of future; special nutrients. Food processing and product development; regulating food processing and preservation through TQM and HACCP. GM foods and their health implications; functional foods and organic foods, impact of WTO in food regulation.

Practical

Product development and shelf life of nutritionally fortified foods using advanced technologies, field study of food processing and preservation in relation to TQM and HACCP in an industry.

FSN 605 ***Advances in Energy Metabolism*** **(1+0)**

Theory

Scope and application of bioenergetics for human nutrition; energy types, energy store in man, its components and measurements. Methods of estimation of energy requirement; factors affecting energy requirements and expenditure. Thermogenesis; interrelationship between metabolic regulation. Mechanism of hunger and its energy cost of macromolecules. Weight control and obesity-role of adipose tissues. Effect of hormones on energy metabolism.

FSN 606 ***Nutrition and Agriculture Interface*** **(1+0)**

Theory

Food situation in India and in the world, food production and consumption trends; food balance sheets. Role of nutrition in agricultural planning and national development. Linkages between agricultural practices; food production, food distribution and nutritional status; food crop failure and malnutrition; poverty and vicious cycle of low food production ; consumption indicators, nutritional status indicators and their role in agricultural planning. Agricultural development and its effect on food availability; effect of food production and economic policies on food availability; impact of physical resources, farming systems, cropping system, inputs and manipulation, agricultural marketing system, post harvest processing of foods on food and nutrition situation; food distribution systems. Food and nutrition security at national and household level; nutrition policy implementation; nutritional impact of agricultural programmes, food price control and consumer subsidy; contribution of national and international organization for agricultural development.

FSN 607 ***Nutrition in Emergencies*** **(1+0)**

Theory

Starvation in emergencies arising out of drought, floods, earth quakes, locust, war, policies and poverty; historical perspectives. Effect of inflation, short, medium and long term emergencies on

food and nutrients intake, precautions against food shortage. Food needs at national level during normal emergencies, Major nutritional deficiency diseases in emergencies; mobilization of local resources; general fund distribution; mass and supplementary feeding; therapeutic feeding; social funds. Control of communicable diseases; public health and hygiene problems during emergencies.

FSN 608 ***Application of Biotechnology in Foods and Nutrition*** **(2+0)**

Theory

History, processes and products of biotechnology; application of biotechnology in production of nutritious foods. Role of biotechnology in enzymology and product development, fermentation process, fruit juice extraction, genetic improvement of food grade microorganisms. Nutritional significance of food products developed by biotechnological techniques. Scientific, technological and resource constraints on biotechnology; important factors affecting development in biotechnology.

FSN 609 ***Global Nutritional Problems*** **(1+0)**

Theory

Food consumption pattern of developed and developing countries. An overview of world nutrition situation and assessment of problems of developing countries in light of prevalence, etiology, Indicators and preventive measures. An overview of world nutrition situation and assessment Problems of developed countries in light of Prevalence, etiology, indicators and preventive measures. Nutrition and health programmes to alleviate malnutrition; role of national and international organizations.

FSN 610 ***Maternal and Child Nutrition*** **(1+1)**

Theory

Current scenario of maternal and child nutrition; Nutritional aspect of embryogenesis; Factors affecting outcome of pregnancy; Physiological changes in body composition and mental development in relation to prenatal and postnatal nutrition. Effect of nutritional

status of mother on quantity and quality of breast milk; recent guidelines in infant feeding and complementary feeding. Feeding of premature babies; HIV and breast feeding; drug abuse and breast feeding. Nutritional problems and requirements of preschool and school going children; growth and development of children; growth monitoring using growth charts. Strategies to improve maternal and child health in India ; role of BPNI in promotion of breast feeding in India; importance of world breast feeding week.

Practical

Preparation of a database on prevailing supplementary and weaning practices- planning, collecting data, analyzing data, writing report; preparation of low cost complementary foods. Analysis of weaning/complementary foods for its nutrient content.

FORESTRY AND ENVIRONMENT SCIENCES

Course No.	Title	Credits
FES 601	Bioremediation	1+1
FES 602	Advances in Forest Genetics Resources & Tree Breeding	1+1
FES 603	Industrial wastes – Impacts on Agro-Ecosystem	1+1
FES 604	Advances in Agro-forestry Systems and Management	2+0
FES 605	Green Technologies and Environmental Protection	1+1
FES 606	Advances in Forest Regeneration	1+1
FES 607	Advances in Silviculture	2+0
FES 608	Kinetics of Waste Water treatment	1+1
FES 609	Climate change: consequences and mitigation strategies	1+1
FES 610	Recycling of Wastes: Soil and microbial processes	1+1
FES 611	Advances in Tropical Ecology	1+1
FES 612	Forest Ecosystem Services & livelihood benefits	1+1
FES 613	New tools in conservation & Field Ecology	1+1
FES 614	Ethno-biology and Tribal Welfare	1+1
FES 615	Advanced wildlife Management	1+1
FES 671	Qualifying Examination (External)	03
FES 681	Seminar	04
FES 691	Research	38

FES 601 ***Bioremediation*** **(1+1)**

Theory

Principles and Processes of Bioremediation**;** Bioremediation in soil- influence of soil properties on organic contaminants and

bacteria. Bioremediation of hydrocarbon**:** Biodegradation of BTEX hydrocarbons under anaerobic conditions - Petroleum contamination - environments contaminated by polycyclic aromatic hydrocarbons - nitro aromatic compounds - Bioremediation of heavy metals**:** microbial remediation of metals. Bioremediation for industrial wastes: Bioremediation of contamination due to industrial wastes disposal - tannery effluent, paper and pulp effluent – mine dump site. Molecular techniques**:** Molecular techniques in bioremediation.

Practical

Site selection process for bioremediation - characterization of the selected sites – process identification and up-gradation for specific wastes - Bioremediation of specific tasks - ground water contamination due to nitro-aromatics, metals, chromium and their bioremediation. Remediation of land and water contaminated by paper factory effluent - Micro, Algal and phyto-remediation techniques

FES 602 ***Advances In Forest Genetic Resources & Tree Improvement*** **(1+1)**

Theory

Forest genetic Resource Conservation: Forest Genetic diversity: Genetic structure of forest populations, Genetic Erosion, Assessment of genetic diversity, Effect of sampling on genetic diversity, factors influencing levels of genetic diversity in woody. Conservation of genetic diversity: gene and population conservation, In situ and ex situ conservation techniques. Breeding Methodologies of forest species: Conventional breeding techniques: Breeding techniques for forest species, problems of difficulties. Advanced techniques: MAS, population selection. Breeding Forest trees: Prospects of tree breeding: advantages and difficulties. Tree breeding techniques: Natural variation as a basic tool for breeding trees, definition of provenances, delineation of provenances, G X E interactions. Methods of tree breeding- conventional and advanced, mating designs. Hybridization as special techniques for trees: Hybrid evaluation using seedling population, merits and demerits. Progeny

testing: GCA, SCA, genetics and combining abilities, Seed clones, pedigree selection. Vegetative propagation of trees: Methods, clonal orchards. Tree breeding for specific traits such as secondary metabolites.

Practical

Synchrony and asynchrony in mating populations; studying genetic variation within and among populations, Estimation of genetic parameters of few traits. Modeling genetic drift, data collection and analysis of heritability, seedling diversity, Visit to species provenances, seed and clonal orchards. Vegetative multiplication.

FES 603 ***Industrial Wastes - Impact on Agro-Ecosystems*** **(1+1)**

Theory

Characteristics of Wastes**:** Major polluting industries in India and Karnataka– over view of tannery, textile, paper and pulp, Sugar and distillery and characteristics of wastes. Air pollution and its effect: Types and sources of pollutants: gases, smokes, particulate matters . Composition of polluted air in industrial sites. Soil acidification and biological indicators of air pollution - effect on agricultural and human health. Effects of fluorides on plant growth and forage quality. Wastewater and crop production**:** Impact of industrial waste water on soil, crops and human health. Utilization of Solid wastes in Agriculture: Types and characteristics of solid wastes – current disposal methods – solid waste management – composting, utilization, recovery by recycling. Bio-sorption of heavy metals present in waste water. Thermal pollution and environmental quality standards: Sources, causes in water bodies and their consequences on metabolic activities of organisms, impacts on agroecosystem and human health and its control.

Practical

Effect of air pollutants on agro- ecosystems – soil and water – impact on plant, microbial and animal metabolisms - heavy metal pollution (chromium, lead, mercury, cadmium) – effect on soil health and agricultural crops – selection of tolerant crops and varieties – waste

water reuse and its implications on agro ecosystems. Solid wastes recycling – use of solid wastes in agriculture – long term effect on cropping systems. Assessment of the effect of specific industrial wastes on agricultural land and crops. Development of treatment process for specific wastes by enrichment and acclimatization.

FES 604 ***Advances in Agroforestry Systems and Management*** **(2+0)**

Theory

Advances in Agroforestry management with emphasis on live fences, boundary plantings, hedgerow intercropping, mixed intercropping, fodder banks, woodlots; Possible experimental designs . Costs and benefits in Agroforestry; Environmental outputs. Discounting rates for private and public economic analysis; Methodology for the exploration and assessment of multipurpose trees General considerations; Collection of MPTs; Assessment and choice of experimental sites; Assessment of methodologies; Changes in plant species; Tree/crop interface approach; Systematic designs; Bivariate analysis for intercropping experiments; Modeling in Agroforestry, Elements.

FES 605 ***Green Technologies and Environmental Protection*** **(1+1)**

Theory

Agricultural productivity**:** Agricultural productivity – Area – Nutrient requirement for major crops – Nutrient loss and pollution in water and land – Plant protection chemicals and weedicides – impact on land and water and biological system. Green technologies: Green technologies – Alternate source for plant nutrients – Biomanure, Vermicompost, Bio fertilizers Plant growth Promoting Rhizobacteria (PGPR). Organic inputs: Green leaf manure – Plant protection measures – Biopesticides – Biocontrol agents - Trap crop for Pest control - Organic agriculture - Concepts and Prospects. Ecosystem management**:** Water management – Ecologically balanced exploitation of soil, water, air resources – Waste utilization. Waste recycling**:** Composting technology for organic waste recycling – Biogas production from solid and liquid waste.

Practical

Integrated farming system – Water conservation techniques – Compost making – Vermicompost preparation- PGPR organism usage – Bio pesticide usage – Bio control agents handling and usage - Eco friendly fruits and vegetable production – Integrated pest management.

FES 606 ***Advances In Forest Regeneration*** **(1+1)**

Theory

Principles and methodologies of Forest regeneration, Ecological basis of natural regeneration techniques, Tree regeneration and its evolutionary trend; Ecological status of woody plants, Choice of species for various sites, Regeneration sampling pattern and intensity. Factors affecting natural and artificial regeneration - Kinds, extent and quality of sites, Relationship of soil characteristics like nutrient, moisture, structure and physiography with tree growth and site productivity; Site manipulation by physical chemical and biological methods. Regeneration in relation to silvicultural systems, Problems of regeneration in respect of important conifers and broad leaved

Practical

Monitoring of forest regeneration, Choosing a regeneration method, Preparation of regeneration plans, Factors promoting natural regeneration, Sampling method and accessing success or failure of regeneration, Modern approaches in container seedling production, INM and irrigation in quality seedling production, Studies on the regeneration techniques of timber and pulpwood species, Cost benefit analysis of regeneration methods.

FES 607 ***Advances In Silviculture*** **(2+0)**

Theory

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 Advance silvicultural practices in rain forest; Tropical forest; Subtropical forest, Temperate forest; Mechanization and role in Silviculture 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 Advances in coppice Silviculture Adjusting silviculture to meet industrial demands

FES 608 ***Kinetics Of Waste Water Treatment*** **(1+1)**

Theory

Kinetics of Wastewater treatment system; factors affecting treatment - microbial growth kinetics – enzymes and enzyme kinetics – microbial kinetics of nitrogen, phosphorous and sulphur removal in wastewater. Characterization of waste waters - quality of various industrial effluents - Sources of pathogens- human risks- pollution of fresh water and estuaries- Fundamentals of waste water treatment technologies- measurement of purification- insoluble materials- soluble matter- concept of oxygen demand- test for biologically degradable organic matter. Methods of wastewater treatment: Aerated lagoons, oxidation ditches and stabilization ponds - activated sludge - microbial community in activated sludge - aerobic digestion, trickling filters - rotating biological contactors - nitrification - biological fluidized bed reactors for treatment of sewage and industrial effluents - anaerobic digestion and anaerobic contact process - denitrification - fluidized bed anaerobic reactors - anaerobic down flow stationary fixed film reactors. Applications of Wastewater treatment:

Practical

Analysis of waste waters for the prevalence of pathogenic organisms - Treatment of waste waters by aerobic and anaerobic methods: aerated lagoons and trickling filters - interaction studies on different microbial communities in different effluent treatment methods Land disposal of waste water - Effect of effluent irrigation

on physical, chemical and microbiological properties of soil and plant growth. Visit to common effluent treatment plants - tannery - dyeing industry - Pulp and paper mill

FES 609 ***Recent Advances In Climate Change*** **(1+1)**

Theory

Recent developments in global climate change: Changes in source and sinks of carbon in the last few decades. Global warming potential of major GHG's. Effect of climate change on: Ocean, Soil, Forest, Biodiversity, Agriculture & livelihood and relevant mitigation measures to address these issues. Climate change, Economic development and energy conservation dilemma. Role of alternate energy sources and its current status towards offsetting fossil fuel use. Carbon Footprint: concepts, methods of assessment, applications and its uses in different fields with special reference to Agriculture. Role of Agroforestry strategies to increase terrestrial carbon sink . Global dimming; Role of aerosols in global dimming and implications to solar energy constant. Policy issues: Kyotoprotocol, Carbon trading mechanisms, Montrial Agreement, Marrakish Accord, REDD, REDD+ and other recent international agreements and negotiations to address the climate change issues. Other climatic aberrations and its relationship to climate change: Ozone depletion, ENSO etc. India's stand on climate change: Recent developments in the strategies; Green India Mission, CAMPA, Millennium goal and other policy initiatives to mitigate climate change.

Practical

Atmospheric CO_2 measurement methods. Soil carbon assessment. Soil carbon dynamics. Atmospheric CO_2 flux measurements. Exposing plants to elevated CO_2 concentration. FACE and FATE experiments, Open top chambers and its importance in understanding the effect of increased CO_2 concentration on plant growth. Differential response of species to elevated CO_2 concentrations. Diurnal plant response to light, temperature and CO_2 concentrations.

FES 610 ***Recycling of Wastes*** **(1+1)**

Theory

Concepts of Compost: Composting - Basic concepts - Clean compost production - Evaluation of compost for stability. Types of composting: Yard waste composting - Sludge composting - Vermicomposting - Low tech composting for small volumes. Composting process: Environmental factors - Microbiology - Biochemistry -Humus formation - Aerobic composting process - anaerobic composting- Advantages and disadvantages. Compost Assessment: Assessing compost maturity - Phytotoxicity - Organic compounds – Trace elements – Heavy metals – Micronutrients - Odour and Volatile organic compounds - Elements of odour management - Standards for compost. Compost and Environmental Management: Environmental consequences - Pathogens - Bioaerosols – Soil physical and chemical manifestations - Biofiltration - Concepts and approaches to regulation - utilization of compost for crop cultivation. -Industrial solid wastes recycling.

Practical

Collection Process for organic wastes - sludges - selection of methods of analysis - isolation techniques for elite organisms - low cost technology for waste recycling - maturity test for composting - composting - standardization of the process - sludges - metal decontamination - study of odour causing compounds - management.

FES 611 ***Advances In Tropical Ecology*** **(1+1)**

Theory

Introduction to the ecological complexity of tropical forests and evolutionary processes of species co-existence. Causes of the origin of tropical species diversity. Present-day ecological factors affecting the distribution of tropical organisms (climatic and topographic heterogeneity). Biological interactions (herbivory, seed dispersal, pollination, coevolution). Monitoring plans to assess potential ecological impacts. Functions of tropical forest; such as nutrient cycling, regeneration and response to disturbances, and

the physiological characteristics of tropical plants. Current threats to tropical biodiversity in the "Era of Globalization" and tourism boom. This includes habitat fragmentation, ecological impacts derived from agricultural and urban sprawling, climate change, and consequences for the dynamics of tropical species. Developing strategies to minimize negative impacts on tropical ecosystems, including restoration ecology, organic agriculture, design of biological reserves and corridors for forest connections.

Practical

Assessment of different ecosystems for species assemblage and co-existance. Evaluation of climatological components for species assemblage. Evaluation of local stresses and its impact on regeneration and species composition. Assessment of biotic and Abiotic factors on ecosystem interaction. Assessment of climate change on ecosystem in terms of growth responses. Assessment of leaf litter on soil physic- chemical components. Impact of forest fragmentation on species dispersion, migration and composition. Phinological and morphological changes on the species.

FES 612 ***Forest Ecosystem Services & Lively Hood Benefits*** **(1+1)**

Theory

Biodiversity as bio-resources; Role of forests resources in human civilization- ex; Easter Island, Indian empires, NTFP, Medici. Plants, economically useful plants as bio-resources for human civilization. Forest as livelihood sources; human dependency on forest, forest –Agril. Interrelations, forest as sources as Agril. Inputs (tangible and non-tangible). Ecosystem services: tangible and non-tangible, environ. Health including water, oxygen and flavor medicines. Pollination services and fertile blooms, predators and parasites, carbon fixation. Forest as source for industry: Genetic resources for biotechnology; BT genes and other microorganisms, Pharma industry, neutral industry, food industry and others. Key stone services: key stone species (ficus, long horned Bill), Key stone relations ex; ficus-wasp symbiosis.

Practical

Assessing contributions of NTFP, med plant and Economic plants from a given forest. Data collection on forest dwellers, survey on their dependence. Study of Agril-Forest interface and assessing the exchange of genetic and biodiversity. Observations on Pollinators and range wild species dependant on pollination. Assessing the diversity of parasites and predators in a given patch of forest. Carbon assessment in forest ecosystem. Visit to bio-prospecting lab to introduce bio-resource to product generation. 8. Studying keystone and key stone relationships.

FES 613 ***New Tools In Conservation And Field Ecology*** **(1+1)**

Theory

Conservation:Top Down and Bottom Up approaches: Concept: Defining the TD and BU; Gene- Ecosystem and Ecosystem to Genes; Advantages and disadvantages, Combining the two approaches. In situ Conservation: Concept: Traditional Concept, Altered views, Advantages, Disadvantages, relevance to forest species. Methodology: Forest Gene Banks, Steps involved in Forest Gene Banks: Mapping viable populations, assessing Genetic diversity and polymorphism of populations, Identifying Source populations and Donor populations, strategies to create gene corridors. Species Recovery Programmes: Identifying species for recovery, Identifying the niches for recovery, Identifying sources populations for replenishing based on genet ic diversity, Production of propagules and replenishing the habitats, Monitoring the establishment. Ex-situ Conservation: Traditional methods: seeds, pollen, tissue. New Methods: DNA, Organelle etc., Techniques involved. Field techniques in Forest Enumeration: Stratifying using NDVI data. Locating and laying transects, Nested plots for various habits. Enumeration and data collection. Computerizing the data and organizing. Mapping and assessing the resource status.

Practical

Tools for Top Down: Spatial mapping tools, Ecosystem Stratification based on topography, Biological and cultural

layers;Tools for Bottom up: Assessing and mapping genetic diversity, Biotech tools, identifying genetic diversity hotspots. Combining the two approaches: Weighing the layers and combining them.

FES 614 ***Ethnobiology And Tribal Welfare*** **(1+1)**

Theory

Ethnobiology - definition, definition of tribe, Cultural traditions, customs, ethos, beliefs and practices. Important tribes of India. Important tribes of Karnataka. Interdependence with forests, role of NWFP in the life of tribes. Tribes and Forest policies - Rights and concessions and fall out. Constitutional safeguards for the welfare of tribes. Role of tribes in Forest and PA management. Tribal development schemes and problems in implementation. Legal provisions to safeguard tribal interests. Ethnic conflicts between tribes and non tribes. Voluntary organizations and tribal development. Tribals and JFM, Indigenous knowledge and tribal development, Ethno medicinal practices and traditional wisdom, Shifting cultivation and tribes. Tribes and forest development works, Eco development through tribal development - Case study of Bandipur/Nagarahole Reserve. Human rights and tribes.

Practicals

Visit to different tribal colonies to understand problems faced by them, Conduct surveys to evaluate the life standards. Visit to different development organizations and NGO's implementing tribal welfare schemes and study about research aspects of Indian tribes. Visit Vana Samrakshana Samiti (VSS) of tribes and understand their role in forest management.

FES 615 ***Advanced Wild Life Management*** **(1+1)**

Theory

History of wildlife management and conservation in India, Zoogeographic regions of the world. IUCN revised red list categories, Red Data Book and red listing, Wildlife census, radio telemetry in wildlife studies. Captive wildlife: Zoos and safari parks.

Captive breeding for conservation. Central Zoo Authority of India. Wildlife (Protection) Act, 1972. Special projects for wildlife conservation. Project Tiger and Musk Deer Project. Captive breeding and reintroduction of threatened species. MAB, CITES, TRAFFIC. Protected area network of India, wildlife sanctuaries, national parks, biosphere reserves.

Practical

Exercise on the census methods, use of soft ware for analysis of census data. Pitfall trap, mist net, Sherman trap, camera trap, and other traps to study the wildlife.

GENETICS AND PLANT BREEDING

Course No.	Title	Credits
GPB 601	Marker Assisted Selection in Crop Improvement	1+1
GPB 602	Intellectual Property Rights and Biosafety in Plant Breeding	2+0
GPB 603	Genomics in Plant Breeding	2+0
GPB 604	Molecular and Chromosomal Manipulations for Crop Breeding	2+0
GPB 605	Advances in Plant Breeding Systems	2+0
GPB 606	Marker Development and Gene Mapping	1+1
GPB 607	Advances in Breeding of Major Field Crops	2+0
GPB 608	Plant Reproductive Stratergies	1+0
GPB 609	Laboratory Techniques in Plant Molecular Breeding	0+1
GPB 610	Plant Genetic Resources and Pre-Breeding	2+0
GPB 611	Advances in Quantitative Genetics	1+1
GPB 612	Crop Evolution	2+0
GPB 613	Breeding Designer Crops	2+0
GPB 614	Advances in Cytogenetics	2+0
GPB 615	Contemporary Plant Breeding Methodologies	2+0
GPB 671	Qualifying Examination	3
GPB 681	Seminar	4
GPB 691	Research	38

GPB 601 ***Marker Assisted Selection in Crop Improvement*** **(1+1)**

Theory

Association of markers with genes; Genetics of DNA markers; Principles of Marker Assisted Selection; Co-segregation and crossing over; Limitation and advantages of Marker Assisted Selection; Role of DNA markers for transfer of major genes and

QTL, Role of markers in backcross breeding and in Pedigree breeding; Major gene – pyramiding using DNA markers; Advantages and limitation of gene pyramiding, DNA marker based detection of genes and QTLs in pyramided plants; Phenotypic evaluation of gene pyramids and detection of gene effects; QTL pyramiding, intricacies and advantages. Development of variety-trait-specific markers and assigning of finger prints; Use of DNA markers in other breeding methods- in mutants, polyploids and transgenics etc; Introduction to Genomics, bioinformatics. Markers Vs Conventional selection; priorities and cost effectiveness; Application of MAS techniques in screening genetically diverse plant species; Examples of successful marker assisted selection in crop plants.

Practical

Working out examples of Marker Assisted Selection in Rice and other crops; Estimating the Genetics of traits using DNA-phenotype combination; Examples of Co- segregation and linkage using markers; Calculating Genetic distances of gene and markers with tagged genes. Estimating the accuracy of marker assisted selection Vs conventional selection; Identifying suitable traits for MAS; Analysis of QTL data and identifying suitable markers for quantitative traits; Interpreting results. Analysing examples of markers and conventional selection. Discussions on usefulness of markers of successful MAS. Prioritizing the selective use of markers for selection in plant breeding.

GPB 602 ***Intellectual Property Rights and Biosafety in Plant Breeding*** **2+0**

Theory

IPR regimes under TRIPS ; Plant Breeder Rights and Patents for crop varieties; IPR under CBD, PGRs and *Sui-generis* system ; Current status of Plant Variety Protection in different countries and existing scenario in India; Plant Variety Protection and Farmer's Right Act 2001 and Rules 2003 ; Farmer's Right on Indigenous Knowledge, Conservation and Benefit sharing ; Material Transfer Agreements and procedure for filing of patents in India ; Patent Convention Treaty ; Transgenics - their handling by public and

private Institutes; Protocols to be followed under DBT guidelines, infrastructure needed; Regulatory issues; Cartagena protocols; Risk assessment for development of resistance in pests; Toxicological aspects, gene escape, GURTS and Bioethics.

GPB 603 ***Genomics in Plant Breeding*** **(2+0)**

Theory

Introduction to the plant genome; Plant nuclear genomes and their molecular description. The chloroplast and the mitochondrial genomes in plants - Genome size and complexity. Databases and other information access. Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants. Approaches for mapping quantitative trait loci; Map based cloning of plant genes. Regulation of Plant gene expression - Functional genomics – Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance-Diversity Array Technology. Genome sequencing in plants– Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches. Detection of Single Nucleotide Polymorphism; TILLING and Eco-TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies-Knock-out mutant studies and high throughput phenotyping. Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

GPB 604 ***Molecular and Chromosomal Manipulations for Crop Breeding*** **(2+0)**

Theory

Organization and structure of genome – Genome size – Organization of organellar genomes – Nuclear DNA organization – Nuclear and Cytoplasmic genome interactions and signal transduction; Transcriptional and Translational changes, Inheritance

and expression of organellar DNA; Variation in DNA content – C value paradox; Sequence complexity – Introns and Exons – Repetitive sequences – Role of repetitive sequence.

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, loclalization and mapping of genes/genomic segments; Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids. Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/A chromosome translocations and gene location. 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. Barriers to interspecific and intergeneric hybridization-Behaviour of interspecific and intergeneric crosses;

GPB 605 ***Advances in Plant Breeding Systems*** **(2+0)**

Theory

Facts about plant breeding before the discovery of Mendelism; Evolutionary concepts of genetics and plant breeding - Flower development and its importance; genes governing the whorl formation and various models proposed; Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination. Self- incompatability and sterility – Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility - Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility: male and female sterility – Types of male sterility: genic, cytoplasmic and cytoplasmic-genic; Exploitation in monocots and dicots, difficulties in exploiting

CGMS system in dicots – Case studies and breeding strategies; Nucleocytoplasmic interactions with special reference to male sterility –Genetic , biochemical and molecular bases. Population formation by hybridization - Types of populations – Mendelian population, gene pool, composites, synthetics etc.; Principles and procedures in the formation of a complex population; Genetic basis of population improvement. Selection in self-fertilizing crops; Creation of genetic variability selection methods - Selection methods: mass selection, pure-line selection, pedigree method (selection in early generations vs advanced generations); Backcross, polycross and test cross. Selection in cross fertilizing crops – Polycross and topcross selections, Mass and recurrent selection methods and their modifications – Mass selection: grided mass selection, ear to row selection, modified ear to row selection; Convergent selection, divergent selection; Recurrent selection: Simple recurrent selection and its modifications (restricted phenotypic selection, selfed progeny selection and full sib recurrent selection) - Recurrent selection for General Combining Ability (GCA) – Concepts and utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities; Prospects and problems - Use of self-incompatability and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male steriles - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genetic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding - Incongruity – Factors influencing incongruity - Methods to overcome incongruity mechanisms.

GPB 606 ***Marker Development and Gene Mapping*** **(1+1)**

Theory

Concepts of RFLP, RAPD, SSR, AFLP, SCAR, STS, CAPS, EST, SNP and marker development; Study of Gene based markers and candidate genes; Utilization of markers and genes in map construction; Assigning of markers to chromosomes with their distances; Selection of suitable population for QTL mapping using DNA markers; software for construction of genetic map, MAPMAKER EXP and other software to detect genes and its back-end functions; examining the Output of gene map; Fixing linear order and distances of markers on chromosomes, Interpretation and assigning linkage groups; Use of trisomics, and cytogenetic maps for assigning markers to linkage groups; Generation of data for phenotype and genotypes. Major gene mapping and location of genes to linkage groups; Estimation of crossing over and linkage of markers and genes.

Practical

Different types of plant material used in mapping, Steps in map construction; Generation of marker data for linkage analysis; scoring of data and stastical analysis. Fixing of threshold LOD; Maximum likelihood and Kosambi functions; Multipoint linkage analysis for detection of linked markers. Procedure for Development of mapping populations; Usage of QTL-MAPMAKER, Cartographer and other softwares used in gene mapping. Single marker analysis; Interval mapping; Linkage disequilibrium, population structuring and Association mapping;; Interpretation of QTL analysis output, QTL nomenclature; Examples of successful QTL mapping. and their uses.

GPB 607 ***Advances in Breeding of Major Field Crops*** **(2+0)**

Theory

Variability and its conservation, significance of gene-action and variance components; Genotype - Environment interaction and adaptation; Selection and its genetic significance - *In vitro* selection; Concept of physiological efficiency; Intergenotypic competition -

Wide crosses and their uses in plant breeding ; Incompatibility and male sterility ; Development of hybrids ; Early generation testing, Population improvement- ; Participatory Plant Breeding; Transgenic varieties; Crop variety development and release at country level; International Crop improvement centres and their programmes. History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non-cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum, Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

GPB 608 ***Plant Reproductive Stratergies*** **(1+0)**

Theory

Reproductive systems in seed plants, Asexual and sexual modes of reproduction; evolution of sex; sex determination in plants; breeding systems- Hermophroditism, dioecy, monoecy and their variants, incompatibility and male sterility systems; Floral diversity and pollination; Floral morphology- shape, colour, size, fragrance and nectar; sex ratio variation; P/O ratios variation; floral cues and pollinations; signal and rewards; post -pollination phenomena; buzz pollination' Optimal and actual out crossing in plants; Role of vectors in gene flow, phenological patterns. Sexual selection and parental manipulation in plants; pollen competition; maternal choice; kin recognition / selection and parent-offspring conflict. Applied pollination biology; Role of insects in agricultural productivity with special reference to hybrid seed production.

GPB 609 ***Laboratory Techniques in Plant Molecular Breeding*** **(0+1)**

Practical

Laboratory equipments needed for plant molecular biology experiments, safety considerations in handling chemicals, and proper disposal of by-products and wastes, Lab etiquette. Laboratory

techniques for DNA and RNA extraction, purification, quantification and visualisation. DNA digestion and DNA transfer techniques. RFLP, PCR, RAPDs, Microsatellites, SNPs and genes used in selecting desired traits for rapid selection. Marker assisted back cross breeding for shortening of breeding cycles. DNA finger printing of important varieties and molecular characterization of plants and pathogens. Reading and documenting results. Data analysis and interpretation. using of results and applications.

GPB 610 ***Plant Genetic Resources and Pre-breeding*** **(2+0)**

Theory

Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes. Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation. Germplasm conservation- *in situ, ex situ,* and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources. PGR data base management; Multivariate and clustering analysis, descriptors; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets. Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre-Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality. Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of

transferred genes and their expression. Post-genomic tools for genetic enhancement of germplasm; Pre-breeding through chromosome manipulation; Application of biotechnology for Genetic enhancement-Achievements. Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement / Prebreeding for crop improvement including hybrid development.

GPB 611 ***Advances in Quantitative Genetics*** **(1+1)**

Theory

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

Practical

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of software in analysis and result interpretation - Triallele analysis– use of software in analysis and result interpretation - Quadriallele analysis – use of software in analysis and result interpretation - Triple Test Cross (TTC) – use of software in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analyse Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Components 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.

GPB 612 ***Crop Evolution*** **(2+0)**

Theory

Origin and evolution of species; Centres of diversity/origin, diffused centres; 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. 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 – Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions. Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction – Intergenomic 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. Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, use of autopolyploids; haploidy-method of production and use; allopolyploids- synthesis of new crops; - Case studies – Cereals – Pulses – Oilseeds – vegetables, Fibre crops - Plantation crops – Forage crops – Tuber crops – Medicinal Plants.

GPB 613 ***Breeding Designer Crops*** ***(*2+0)**

Theory

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins,

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

GPB 614 ***Advances in Cytogenetics*** **(2+0)**

Theory

Principles and procedures of genome analysis, colinearity among genome and synteny, Use of conventional and modern techniques, morphological cytological, genetical, biochemical and molecular tools used in major crops like wheat, rice, maize, sugarcane, brassica, cotton, tobacco, potato; Location and mapping of genes on chromosome by different methods – conventional, monosomics, telocentric method; Identification of chromosomes involved; balanced lethal system- its maintenance and utility; Trisomic-types, breeding behaviour, balanced tertiary trisomics & their use in hybrid seed production; Gene transfer by distant hybridisation - Alien chromosome addition and substitutions, chromosomal control of meiotic pairing and induced transfer of alien genes.

GPB 615 ***Contemporary Plant Breeding Methodologies*** **(2+0)**

Theory

Current breeding methods and bottle necks; Genetic basis of traits; gap in lab to land and yield production; Modern breeding

tools available to bridge the gap; Anticipatory plant breeding, situations and conditions, prioritorising traits/varieties; Utilization of genes from farmers varieties. The gaps in traditional breeding methodologies; Farmers priorities and perceptions of crop improvement. Farmer Participatory varietal breeding and Farmer participatory varietal selection, bridging the gap between the farmers and the scientists perceptions and feed back.. Prioritizing Crops/ traits/varieties suitable for farmer participatory breeding. Benefits of farmers' involvement. Application of contemporary breeding tools and methodology in breaking yield barriers. Designing mother-baby trials and Statistical tools for analyzing mother-baby trial data, selection process in mother and baby trials; Role of Traders, consumers, farmers and scientists in plant breeding; Public and private partnerships for varieties/Hybrids/transgenics, credit sharing and seed production and seed supply; Farmers as decision makers in breeding process and credit sharing; Role of women in Farmer Participatory Trials and their priority; Farmer Participatory Conservation of local varieties/ land races. Examples of success stories of farmers participatory selection and breeding.

HORTICULTURE

Course No.	Title	Credits
HRT 601*	Advances in production technology of fruits	2+1
HRT 602*	Advances in production technology of vegetable crops	2+1
HRT 603*	Advances in production technology of commercial flowers	2+1
HRT 604*	Advances in production technology of plantation, spices, medicinal and aromatic crops	2+1
HRT 605*	Advances in post-harvest technology in horticulture crops	2+1
HRT 606	Advances in breeding of fruit crops	1+1
HRT 607	Advances in breeding of vegetable crops	1+1
HRT 608	Advances in plant propagation of fruit crops	1+1
HRT 609	Advances in nutrient management of fruit crops	1+1
HRT 610	Advances in landscape gardening	1+1
HRT 611	Biotechnology of fruit and plantation crops	1+1
HRT 612	Biotechnology of vegetable and flower crops	1+1
HRT 671	Qualifying Examination	03
HRT 681	Seminar	04
HRT 691	Research	38

*** core courses**

Core courses (15 credit hours)

HRT 601 ***Advances in production technology of fruits*** **(2+1)**

Theory

National and International scenario in fruit production. Exhaustive review of research findings on topics of crop improvement, propagation techniques, rapid multiplication techniques; horticultural practices, like High density planting, crop modeling, nutrient management, irrigation management, fertigation,

weed control, use of growth regulators, major pests, diseases and physiological disorders in the following tropical, subtropical and temperate fruit crops *viz.*, mango, banana, grapes, *Citrus* sps., sapota, guava, papaya, pineapple, pomegranate, jackfruit, fig, aonla, avocado, apple, peach, pear, plum, cherry, apricot, strawberry and nut crops. Total Quality Management (TQM) and current topics.

Practicals

Recent techniques in fruit breeding, modern methods of propagation, integrated nutrient management practices, application of growth regulators, water management and plant protection practices. Dry land fruit orchard management practices and organic production of fruit crops. Fruit tree canopy management. Visit to commercial nurseries and research institutes.

HRT 602 ***Advances in production technology of vegetable crops*** **(2+1)**

Theory

Present scenario and prospects of vegetable cultivation in India; recent advances in crop production practices; factors limiting vegetable production; nursery management, plant geometry and density, seed production technique, choice of varieties and hybrids, multiple cropping systems, crop growth regulation, mineral nutrition and fertigation, integrated nutrient management; herbicide application, mulching, irrigation management, mechanization, plant protection, harvesting, hydroponics, Nutrients Film Technique (NFT), curing, drying of important vegetable crops such as tomato, brinjal, chilli, sweet pepper and potato, cucurbits like cucumber, muskmelon, watermelon, gourds and pumpkin, cabbage, cauliflower, knol-khol, broccoli, brussels sprouts, bhendi, onion, peas, beans, amaranthus and drumstick, carrot, beet root, radish, sweet potato, tapioca, elephant foot yam and taro. Integrated pest management in vegetable crops. Special techniques in vegetable farming. Protected cultivation of vegetables.

Practicals

Diagnosis of nutritional and physiological disorders, assessing nutrient status of plants, application of plant growth substances, practices in herbicides application, estimating water requirements in relation to crop growth stages, fertigation, maturity indices, and

quality analysis. Visit to commercial nurseries and research institutes.

HRT 603 ***Advances in production technology of commercial flowers*** **(2+1)**

Theory

Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Special practices in cut and loose flowers. Dry flower technology. Advances in propagation, IPR issues and plant quarantine; Greenhouse management; Soil/media decontamination techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers; influence of environmental factors-light, temperature, moisture, humidity and CO2 on growth and flowering; growth regulation for quality flowers. Flower forcing and year-round flower production through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing; Export potential; Agri Export Zones. Crop specific practices – rose, chrysanthemum, anthurium, orchids, carnation, gladiolus, gerbera, liliums, china aster, Jasminum marigold, tuberose and crossandra.

Practicals

Varietal wealth in flower crops; Greenhouse management; Soil sterilization techniques; Micro-irrigation; Nutrition and fertigation. Special practices- Pinching, netting, disbudding, defoliation and chemical pinching; Photoperiodic and chemical induction of flowering; Assessing harvest indices; Post-harvest handling; Preparation of floral decoratives; Visit to commercial nurseries and research institutes.

HRT 604 ***Advances in production technology of plantation, spices, medicinal and aromatic crops*** **(2+1)**

Theory

Scope and prospects of production of important plantation and spice crops like coffee, tea, cocoa, rubber, cashew nut, coconut, areca nut, oil palm, black pepper, small cardamom, ginger, turmeric, tree, seed spices. Medicinal and aromatic crops like coleus, amla, ashwagandha, isabgol, senna, periwinkle, aloe vera, aromatic

grasses, mints, geranium, patchouli. Advances in the propagation and crop improvement, water management, fertigation, use of growth regulators on plantation, spice, medicinal and aromatic crops. Designing multi-tier cropping system for high productivity in coconut and arecanut gardens. Integrated nutrient management and integrated management of pests and diseases.

Practicals

Detailed studies on high density planting systems, application of growth regulators, recent advances in propagation, extraction methods, pest and disease management in plantation, spice, medicinal and aromatic crops. visit to research institutes and processing units.

HRT 605 ***Advances in post-harvest technology in horticulture crops*** **(2+1)**

Theory

Metabolic process of harvested product, respiration, transpiration, photosynthesis, climacteric phenomenon in fruit and vegetable, ripening process, natural and artificial, biosynthesis of ethylene and its effect on issue on metabolism. Packaging of fruits and vegetable, package design, package type monitoring of packing material, MA packing. Storage design and methods – CA, MA and different type of storages, barrel, clamps, pits, cellars, evaporative coolers solarization, cold storages. Molecular biology of ripening, covert changes, overt changes in ripening. Biochemical metabolism. Carbohydrates, fat, proteins, flavor compounds, anthocynin pigment, post-harvest treatment, pre-cooling growth regulators, skin coating, vapour heat treatment and irradiation. Post harvest physiological disorders and diseases of fresh fruits and vegetables and cut flowers .

Practicals

Study of harvesting, grading, sorting, packing, storage, transportation and marketing system. Judging and maturity indices of horticultural crops. Classification of packing materials and different transportation systems, shipment, road ways, railways and air cargo. Study of different storage structures, group discussion on national and international laws for import and export of fresh products. Post harvest operations of fresh product. Post harvest operations of fresh product safety, hygiene and quality of fresh

produce. Strategies for maturity for marketing of fresh produce, market analysis and information, intelligence. Visits to safal markets and commercial cold storages

Minor courses (14 credits hours)

HRT 606 ***Advances in breeding of fruit crops*** **(1+1)**

Theory

General introduction and significance; methods and advancement in breeding with special reference to mango, banana, *Citrus* sps., grape, apple, pear, stone fruits, temperate nuts, arid zone fruits. Overcoming breeding problems-long juvenile phase, hybrid sterility, gametophytic incompatibility; genetic and phylogenetic relationship, inheritance of economically important traits; rootstock breeding : breeding for resistance to biotic and abiotic stresses, transgenic fruit plants, future thrusts. Use of markers in fruit crops breeding.

Practicals

Determination of cross –compatibility /incompatibility using *in vivo* pollen tube growth studies: embryo rescue culture technique. Cytological and isozymic studies in cultivars identification.

HRT 607 ***Advances in breeding of vegetable crops*** **(1+1)**

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, in vitro breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of Tomato, Brinjal, Chilli, Sweet Pepper and Potato.

Cucurbits like cucumber, muskmelon, watermelon, gourds and pumpkin, cabbage, cauliflower, knol-khol, bhendi, onion, peas, beans, amaranthus and drumstick, carrot, beet root, radish, sweet potato, tapioca, elephant foot yam and taro.

Practicals

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

HRT 608 ***Advances in plant propagation of fruit crops*** **(1+1)**

Theory

Advanced methods of propagation. Internal and external factors influencing seed germination : physiological, anatomical and biochemical basis of root induction, callusing and formation of bud/ graft union; stock-scion relationship, physiology of dwarfing rootstocks. Mist propagation, *in vitro* propagation techniques –high volume production system, mass micro propagation, hardening technique and use of phytopackaging and transportation of micropropagules / Certification of planting materials through molecular markers.

Practicals

Different propagating structures, preparation of media, vegetative methods of propagation, anatomical studies on rooting of cuttings, curing and hardening of rooted cuttings, raised through mist propagation, tissue culture techniques including handling and transportation of micropropagules

HRT 609 ***Advances in nutrient management of fruit crops*** **(1+1)**

Theory

Nutrient sources-Nitrogen, Phosphorus and Potassium fertilizers and manures, essential plant nutrients-functions and deficiency symptoms. Special features of nutrition of fruit corps. Plant and soil analysis as a guide for fertilization of fruit crops. Factors affecting nutrition, scion and stock relationships, effects of

nutritional factors on cold hardiness of plants. Bio-fertilizers and their importance in crop production. Micronutrients –critical limits in soils and plants, factors affecting their availability and correction of their deficiencies. Controlled release of fertilizers. Nutrients film techniques, fertigation, Distribution and effectiveness of the root system. Methods to investigate tree root system. Fertilizer use efficiency, Current nutritional problems.

Practicals

Leaf sampling techniques in various fruit crops. Methods of analysis of leaf and soil samples. Study of modern instrumental method of analysis. Isolation, identification of different species of vesicular arbescular mycorrhiza fungi. Pot experiments to study the effect of different microorganisms on growth and nutrient uptake of nursery seedlings, root activity in fruit crops by tracer methods.

HRT 610 ***Advances in landscape gardening*** **(1+1)**

Theory

Modern trends in the use of elements and principles of landscape design. Use of computers in landscape design. Developing computer Aided Design (CADD). Use of data base of landscape plants in landscaping of different places. Use of garden adornment. interior landscaping and xeriscaping. Bioaesthetic planning of urban towns, highways, industrial areas, golf courts and traffic islands. Sources and nature of pollutants, sensitivity and resistivity of plants to air pollutants. Bonsai, flower arrangement, terrariums, terrace gardening, vertical gardening.

Practicals

Planning and layout of different types of gardens. Preparation of landscape plants of places of public importance. Map reading and interpretation. Making drawings of garden adornments like arches, pergola, water gardens. Learning the basics in computer aided design (CADD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing. Contemporary landscaping. Monitoring and mapping of pollution with the help of plants. Planning of urban landscape designs.

HRT 611 ***Biotechnology of fruit and plantation crops*** **(1+1)**

Theory

Plant tissue culture- a historic perspective, methods of *In vitro* culture with respect to fruit and plantation crops. Methods followed for *In vitro* production of secondary metabolites. General introduction and history of biotechnological approaches for crop improvement in fruit crop. Applications of molecular markers, transgenics, detection methods, bio-safety issues and tissue culture technologies for improvement of fruit crops. Advances made in fruit crops with reference to genomics in mango, banana, *Citrus* sps, grapes, papaya, apple, plum, apricot & other minor fruits. cardamom, pepper, ginger, coconut, arecanut and other plantation crops.

Practicals

Preparation of plant tissue culture media, aseptic initiation of plant cultures using various explants, production of secondary metabolites using callus and suspension cultures. Plant genomics DNA isolation from leaf samples, PCR amplification using RAPD/ SSR/SARP markers. Gel electrophoresis and documentation. Data scoring and analysis using software's. Data interpretation and drawing conclusions.

HRT 612 ***Biotechnology of vegetable and flower crops*** **(1+1)**

Theory

Introduction, definition and branches of biotechnology. Improvement of vegetables and flower crops through tissue culture methods *viz.*, micro propagation, meristem culture, protoplast culture, cell suspension culture, embryoculture, somatic hybridization, ovule culture, anther culture, *In-vitro* pollination etc. Application of molecular markers, transformation techniques and bio-safety issues for improvement of vegetables and flower crops. Use of biotechnology for the production of bio-agents and bio-fertilizers. Exploitation of biotechnological applications for improvement of vegetables and flower crops.

Practicals

Introduction to biotechnology laboratory, preparation and sterilization of plant tissue with media, establishment *In-vitro* culture in vegetables and flower crops. Molecular markers study using RAPD, SSRs, AFLP etc., Plant transformation techniques, detection of transgenics by PCR, western blot method.

PLANT BIOCHEMISTRY

Course No.	Title	Credits
BCM 601	Advanced Enzymology	2+0
BCM 602	Advanced Molecular Biology	3+0
BCM 603	Biochemistry of Biotic and Abiotic Stresses	3+0
BCM 604	Current Topics in Biochemistry	1+0
BCM 605	Genomics, Proteomics and Metabolomics	3+0
BCM 606	Biomembranes	2+0
BCM 607	Advanced Techniques in Biochemistry	0+2

BCM 601 ***Advanced Enzymology*** **(2+0)**

Theory

Theory of enzymatic catalysis, specificity, concept of active site and enzyme substrate complex, active site mapping, acid-base and covalent catalysis, factors associated with catalytic efficiency, proximity and orientation, distortion and strain, induced fit hypothesis, Mechanism of enzyme reactions. Effect of different factors affecting enzyme activity, transition state theory, Arrhenius equation, Determination of energy of activation, kinetics of pH and temperature and determination of pKa and OH of active site amino acids. Kinetics of bisubstrate reactions, mechanism determination by radioisotope exchange, kinetics of mixed inhibitions, substrate and product inhibition. Role of enzymes in regulation of metabolism, allosteric enzymes and their kinetics, enzyme engineering, Bifunctional enzymes, enzyme engineering,

BCM 602 ***Advanced Molecular Biology*** **(3+0)**

Theory

Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping, molecular evolution, cell development and differentiation. Prokaryotic and eukaryotic gene regulation, RNA editing, molecular biology of viruses.

Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility, Application of genetic engineering in different fields. Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

BCM 603 ***Biochemistry of Biotic and Abiotic Stresses*** **(3+0)**

Theory

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

BCM 604 ***Current Topics in Biochemistry*** **(1+0)**

Theory

Advanced topics related to nutrition and metabolism. Advanced topics related to enzymology and industrial biochemistry. Advanced topics related to molecular biochemistry and immunology. Advanced topics related to metabolic engineering and bioprospecting.

BCM 605 ***Genomics, Proteomics and Metabolomics*** **(3+0)**

Theory

Protein and nucleic acid sequencing: Various methods of sequencing including automated sequencing and microarrays, whole

genome sequence analysis. Comparative genomics, functional genomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, Quantitative PCR, SAGE, MPSS, microarray. Proteome technology-2D-PAGE, MSMS, MALDI-TOF, protein microarray, comparative proteomics and structural proteomics. Metabolic pathway engineering, vitamin A engineering in cereals, micro-array analysis, role of bioinformatics in functional genomics.

BCM 606 ***Biomembranes*** **(2+0)**

Theory

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen. Membrane biogenesis and differentiation; membrane components-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function. Various membrane movements; transport across membrane and energy transduction. Role of membrane in cellular metabolism, cell recognition and cell –to – cell interaction; signal transduction, recent trends and tools in membrane research.

BCM 607 ***Advanced Techniques in Biochemistry*** **(0+2)**

Theory

Isolation and purification of protein from microbial/plant/ animal source. Electrophoretic separation of protein. Determination of molecular weight of protein using PAGE/ gel filtration method. Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA. Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation. Isolation and purification of enzymes, isozymic analysis and enzyme immobilization.

PLANT BIOTECHNOLOGY

Course No.	Title	Credits
PBT 601	Advances in Plant Molecular Biology	2+0
PBT 602	Advances in Genetic Engineering	2+1
PBT 603	Advances in Microbial Biotechnology	1+1
PBT 604	Advances in Crop Biotechnology	2+1
PBT 605	Advances in Functional Genomics and Proteomics	3+0
PBT 606	Commercial Plant Tissue Culture	1+1
PBT 607	Advances in Animal Biotechnology	2+0
PBT 671	Qualifying Examination	3
PBT 681	Seminar	4
PBT 691	Research	38

PBT 601 ***Advances in Plant Molecular Biology*** **(2+0)**

Theory

Arabidopsis in molecular biology, Forward and Reverse Genetic Approaches, Transcriptional and post-transcriptional regulation of gene expression, isolation of promoters and other regulatory elements. RNA interference, Transcriptional gene silencing, Transcript and protein analysis, use of transcript profiling to study biological systems. Hormone regulatory pathways: Ethylene, Cytokinin, Auxin and ABA, SA and JA; ABC Model of Floral Development, Molecular basis of self incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms. Molecular biology of abiotic stress responses: Cold and high temperature, submergence, salinity and drought; Molecular Biology of plant-pathogen interactions, molecular biology of *Agrobacterium* infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis), Programmed cell death in development and defence.

PBT 602 ***Advances in Genetic Engineering*** **(2+1)**

Theory

General overview of transgenic plants; Case studies: Genetic engineering of herbicide resistance, Transgenic plants resistant to insect/pests, Genetic engineering of abiotic stress tolerance, Engineering food crops for quality, Genetically engineered pollination control, Induction of male sterility in plants. Molecular farming of plants for applications in veterinary and human medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts. Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants. Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Practical

Isolation of Ti Plasmid, construction of recombinant Ti Plasmid, transformation, transfer through other methods; detection of transgene by PCR; Expression of reporter genes, expression of marker genes, confirmation of the expression by southern and northern blot analysis; Detection of the proteins produced by SDS analysis and western analysis; Bioassay of the proteins if the reporter gene is an enzyme like GUS & Lac Z; UV visualization for GFB.

PBT 603 ***Advances in Microbial Biotechnology*** **(1+1)**

Theory

Fermentative metabolism and development of bioprocessing technology, processing and production of recombinant products; isolation, preservation and improvement of industrially important

microorganisms. Immobilization of enzymes and cells; Batch, plug flow and chemostat cultures; Computer simulations; Fed-batch and mixed cultures; Scale-up principles; Down stream processing etc. Current advances in production of antibiotics, vaccines and biocides; Steroid transformation; Bioreactors; Bioprocess engineering; Production of non-microbial origin products by genetically engineered microorganisms. Concept of probiotics and applications of new tools of biotechnology for quality feed/ food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Factors affecting delignification; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Single cell protein, Bioinsecticides; Biofertilizers; Recent advances in microbial biotechnology.

Practical

Isolation and culturing industrially important microorganisms; culturing techniques – batch and chemostat cultures; immobilization of enzymes for substrate conversion; isolation of secondary metabolites from microorganisms; screening elicitors from microorganisms for antibacterial and antifungal components; biofermentor and its applications; lactic acid fermentation through bio-fermentors; biochemical analysis for the production of aldehydes and organic acids from micro-organisms; production and quality control aspects of bio-inoculants and biofertilizers.

PBT 604 ***Advances in Crop Biotechnology*** ***(*2+1)**

Theory

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement. Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by

manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc); edible vaccines, etc. Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker- assisted selection for qualitative and quantitative traits.Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major field crops such as rice, wheat, cotton, maize, soybean, oilseeds, sugarcane etc.

Practical

Isolation of Bt Strains; Characterization of cry proteins and cry genes, bioassay; isolation and characterization of protein; proteinase inhibitors, bioassay; isolation and characterization of lectins and their bioassay; isolation of chitinases and genes for chitinases from different samples; Bioassay against fungal pathogens, isolation of PR proteins, assay of PR proteins against disease causing organisms, isolation of HSP's and genes, assay to determine the role of HSP's in salinity and temperature stress.

PBT 605 ***Advances in Functional Genomics and Proteomics*** **(3+0)**

Theory

Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc. Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation, domestication etc. Proteomics: protein

annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading; software and data analysis/ management etc. Discussion on selected papers on functional genomics, proteomics, integrative genomics etc.

PBT 606 ***Commercial Plant Tissue Culture*** **(1+1)**

Theory

Micropropagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing. Production of useful compounds via biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry. Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethical issues; management and commercialization. Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/ industries.

Practical

Components of plant tissue culture media and preparation of MS, B5 and Nitsch media; maintenance and selection of mother plant, selection of explants, sterilization of explant and culturing of explant; induction of callus in carrot, tobacco and other crops; induction of cell suspension cultures in carrot, tobacco and other crops; induction of caulogenesis in carrot, tobacco and other crops; induction of rhizogenesis in carrot, tobacco and other crops; invitro propagation of banana – explant selection, preparation and sterilization, media preparation, culture induction, sub culturing, rooting, hardening and *ex vitro* establishment; measurement of growth in callus cultures, organ cultures and cell suspension cultures.

PBT 607 ***Advances in Animal Biotechnology*** ***(*****2+0)**

Theory

Advances in animal cell culture technology, suspension culture technology, advances in commercial scale productions of mammalian cells. Advances in cell cloning and cell hybridization, advances in monoclonal antibody production technology, Advances in diagnostic technology, Computational vaccinology, reverse genetics based vaccines. Advances in embryo manipulation, knock-out and knock-in technology, advances in animal cloning technology, stem cell technology, Advances in development of animal models for human diseases using transgenic animal technology. Advances in genetic basis for animal disease resistance, Molecular methods for animal forensics, Advances in animal genomics and proteomics.

PLANT PATHOLOGY

Course No.	Title	Credits
PAT 601	Advanced Mycology	2+1
PAT 602	Advanced Virology	2+1
PAT 603	Advanced Bacteriology	2+1
PAT 604	Advanced Nematology	2+1
PAT 605	Molecular Basis of Host-Pathogen Interaction	2+1
PAT 606	Principles and Procedures of Certification	1+0
PAT 607	Plant Biosecurity and Biosafety	2+0
PAT 671	Qualifying Examination	3
PAT 681	Seminar	4
PAT 691	Research	38

PAT 601 ***Advanced Mycology*** **(2+1)**

Theory

General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, Chemical (chemotaxonomy), Molecular and Numerical (Computer based assessment) taxonomy. Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi. Population biology, pathogenic variability/vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation. Ultrastructures 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

Practical

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 from different groups of fungi.

PAT 602 ***Advanced Virology*** **(2+1)**

Theory

Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains. Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction. Genome organization, replication, transcription and translational strategies of pararetroviruses and geminiviruses, satellite viruses and satellite RNA genome organization in tobamo-, poty-, bromo, cucummo, ilar and tospoviruses. Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions. Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance,

nucleic acid isolation, DOT-blot, southern hybridization, probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

PAT 603 ***Advanced Bacteriology*** **(2+1)**

Theory

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria, Bacterial growth and kinetics. Current trends in taxonomy of phytopathogenic procarya. Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development, Mechanism of symptom induction, Mechanism of wilt (*Ralstonia solanacearum*) development, mechanism of soft rot (*Erwinia* spp.) development, mechanism of Crown gall formation (*Agrobacterium tumifaciens*). Bacterial virulence and pathogenicity, Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, Effector protein. Bacterial genetics, Molecular variability among phytopathogenic prokaryote and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pathogens-gene silencing, RNAi technology. Epidemiology in relation to bacterial plant pathogens. Development of diagnostic kit. Bacteriophages and plasmids, Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

Practical

Pathogenic studies and race identification; plasmid profiling of bacteria; fatty acid profiling of bacteria; RAPD prolfiling of bacteria and variability status; Endospore, Flagella staining; Test for secondary metabolite production, cyanides, EPS, siderophore; specific detection of phytopathogenic bacteria using species/ pathovar specific primers. Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts.

PAT 604 ***Advanced Nematology*** **(2+1)**

Theory

Nematode anatomy, morphology, biology and ecology. Phylogenetic and evolutionary concepts. Nematode ecology, habitat variations and associated factors influencing nematodes, effects of biotic and abiotic factors on host-nematode interaction, studies on the interaction of nematodes with other microorganisms including arthropods. Molecular, cytogenetical and serological approaches, fine structures in systematics. Culturing, survival, adaptive biology and variability. Sex determination, sensory structures and hierarchies in nematode behaviour in pheromones, receptors and host induced stimuli in communication systems. Genetics of nematode parasitism. Anatomy and ultrastructure of plant responses. Plant deferens and incompatibility. Interactions with fungi, bacteria, mycorrhiza, other nematodes, insects and molecular basis of nematode transmission of viruses. Nematodes as model systems to study biological ageing, nutrition, toxic environmental contaminations and cell motility. Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques. Novel concepts in nematode management-inhibition of steroid/hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Modeling and computer simulations in integrated nematode management programmes

Practical

Mechanism and genetic basis of plant resistance. Breeding for nematode race specific resistance through biotechnological and genetic engineering techniques- recombinant DNA (gene silencing); somatic hybridization and protoplast fusion. Novel concepts in nematode management- inhibition of steroid/hormone metabolism, exploring sensory stimuli, biological activity and mode of action of Avermectins. Identification of indigenous bio-control agents, their mass production and distribution. Modeling and computer simulations in integrated pest management programmes. Internet tools and application in Nematology.

PAT 605 ***Molecular Basis of Host-pathogen Interaction*** **(2+1)**

Theory

Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship. Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction. Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral 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. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

Protein, DNA and RNA isolation, Plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation.

PAT 606 ***Principles and Procedures of Certification*** **(1+0)**

Theory

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. 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.

PAT 607 ***Plant Biosecurity and Biosafety*** **(2+0)**

Theory

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases. 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 (PRA), 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. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops/varieties.

SEED SCIENCE AND TECHNOLOGY

Course No.	Title	Credits
SST 601	Hybrid Seed Production	1+1
SST 602	*In Situ* and *Ex Situ* Conservation of Germplasm	2+1
SST 603	Dus Testing for Plant Variety Protection	1+1
SST 604	Testing for Genuineness & Purity of Cultivars	1+1
SST 605	Seed Storage and Deterioration	2+1
SST 606	Advances in Seed Treatment	1+1
SST 607	Seed Marketing and Management	1+1
SST 608	Advances in Seed Science Research	1+1
SST 671	Qualifying Examination	3
SST 681	Seminar	4
SST 691	Research	38

SST 601 ***Hybrid Seed Production*** **(1+1)**

Theory

Introduction, concepts of hybrid seed production; Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement. Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; basic principles in hybrid seed production. Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines. Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

Practical

Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows/blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots etc.

SST 602 ***In Situ* and *Ex Situ* Conservation of Germplasm** **(2+1)**

Theory

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity. *Ex situ* conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene depositories, preservation of genetic materials under natural conditions, *permafrost* conservation, guidelines for sending seeds to network of active/working collections, orthodox, recalcitrant seeds- differences in handling, clonal depositories, genetic stability under long term storage condition. *In vitro* storage, maintanence of *in vitro* culture under different conditions, *in vitro* bank maintenance for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplastand callus cultures, pollen culture, micropropagation techniques, problems prospects of *in vitro* gene bank. Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants,dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops. Problems and prospects; challenges ahead.

Practical

In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, packaging, documentation; design of cold storage modules-Conservation protocols for recalcitrant and orthodox seeds; Cytological studies for assessing genetic stability, *in vitro* cultures-embryo,cell/suspension cultures,pollen cultures, study of cryotank facility and vitrification techniques, visit to NBPGR/NBAGR -study using fruit crops and other horticultural crops.

SST 603 ***Dus Testing for Plant Variety Protection*** **(1+1)**

Theory

Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions; General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties; Protection of Plant Varieties and Farmers' Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003. Criteria for protection of new varieties of plants; principles and procedures of Distinctness, Uniformity and Stability (DUS) testing; test guidelines, planting material, duration, testing options, varieties of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire. Assessment of DUS characters based on morphological, biochemical and molecular markers; statistical procedures; computer software for use in DUS testing; impact of PVP on growth of seed industry; practical exercise of DUS testing in rice, wheat, pearl-millet, maize, rose and cauliflower.

Practical

Morphological description of plant parts and plant; character expression and states, recording observation and interpretation of data; chemical tests and markers applicable for DUS tests and case study of selected crops.

SST 604 ***Testing for Genuineness & Purity of Cultivars*** **1+1**

Theory

Objective of cultivar purity test, general principles and methods involved. Use and limitations of laboratory, green house and field plot methods in determination of genuineness of cultivars; a case study in hybrid cotton, reporting of results and inference. Chemical-biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein, isozymes etc, use of chromatography for analysis of secondary compounds etc. DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties. Use of computer-based machine vision (MVT) for varietal identification and purity testing etc.

Practical

Chemical and biochemical tests for species and cultivar purity testing: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, use of chromatography for analysis of secondary compounds.

SST 605 ***Seed Storage and Deterioration*** **(2+1)**

Theory

Life span of seeds of plant species; classification of seeds on the basis of storage behaviour; orthodox and recalcitrant seeds; types of storage; kinds of seed storage (open, bulk, controlled, hermetic, germplasm, cryopreservation); soil-seed bank; terminology; survival curve of seed. Factors affecting seed storability- biotic and abiotic and pre- and postharvest factors affecting seed longevity; the effects of packaging materials, storage fungi and insects, seed treatment and fumigation and storage environmental conditions on seed storability; moisture equilibrium in seeds; hysteresis effect; thumb rules; selection of suitable areas/ places for safe storage; prediction of relative storability and longevity of seed lots, viability equations and nomographs. Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and

related theories; different changes associated with the loss of vigour and viability during storage; application of physiological and biochemical techniques for evaluation of seed ageing; genetics of seed viability; effect of seed ageing on crop performance; maintenance of viability and vigour during storage; seed amelioration techniques, mid storage corrections etc. Storage methods-requirement of storage facilities in India; types and storage structures available in the country and their impact on short and long term storage; methods of safe seed storage including eco-friendly techniques used in various group of crops viz. cereals, pulses, oilseeds, fibers, forages and vegetables; operation and management of seed stores; fruit storage; viability loss during transportation and interim storage.

Practical

To study the effect of storage environmental factors (RH, SMC and temperature) on seed longevity; to study the effect of packaging materials, seed treatment and fumigation on storability; prediction of storability and longevity of seed-lots by using viability equations and nomographs; standardization of accelerated ageing (AA) technique for assessing the seed storability of various crops; estimation of carbohydrates, proteins, fats, enzyme activities, respiration rate and nucleic acids in fresh and aged seeds; use of eco-friendly products and amelioration techniques to enhance quality of stored seeds, visit to seed stores.

SST 606 ***Advances in Seed Treatment*** **(1+1)**

Theory

Importance and history of seed treatment – definitions, concepts, classification and methods of seed treatment; Use of different seed treatment materials, seed coating and pelleting, seed colorings, polymer coatings, pesticides and other plant products, bio-inoculants, antibiotics and growth regulators; Physical treatments with abrasives, hot and cold temperature, radio frequency waves, magnetic waves, Micro waves, UV-rays, X-rays and gamma-rays; methods of application and their effects on seed quality - seed germination, seedling vigour, storage, seed health etc; Pre-sowing

and pre-storage seed treatments - seed priming / invigouration, seed hardening, osmo-conditioning for drought and other abiotic stress conditions, mid-storage corrections etc. Bio efficacy of seed treatments, seed quarantine regulations; legal terminologies and labeling requirements, bio-safety measures etc.

Practical

Use of inert, chemical and non toxic materials of plant origin; seed coating and pelleting and its influence on seed quality; physical, chemical and energy treatments and their influence on seed quality; use of bio-fertilizers, bio-inoculants and bio-pesticides, plant products on germination and viability; use of organic solvents for infusing bio-active chemicals for seed enhancement; seed colouring, seed treatment devices, visit to seed processing plant etc.

SST 607 ***Seed Marketing and Management*** **(1+1)**

Theory

Importance and promotion of quality seed, formal and informal seed supply systems. Basic concepts of marketing with special reference to seed; importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector role of seed association / federation in seed trade. Demand and supply of seed; Role of seed replacement rate (SRR), seed multiplication ratio (SMR), cost of production and returns; determining seed needs; seed pricing and price policy, seed processing and /packaging, demand forecasting. Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins. Salient features of national seed policies, role of various sectors/ agencies in efficient seed marketing, quality control and assurance programme. Responsibilities of seed companies and dealers under Seed Act, EXIM policies for seed trade etc.

Practical

Statutory requirements in seed business including R&D, estimation of cost of seed production, marketing costs and margins of seeds of different crops, case studies to compare public & private

sectors in different conditions, impact analysis, seed pricing, cost benefit ratio, economic feasibility of seed industry etc.

SST 608 ***Advances In Seed Science Research*** **(1+1)**

Theory

Physiological and molecular aspects of seed development and control of germination and dormancy; gene expression during seed development; desiccation and stress tolerance and conservation; prediction of seed dormancy and longevity using mathematical models; structural changes in membranes of developing seeds during acquisition of desiccation tolerance; dehydration damage and repair in imbibed seeds, seed biotechnology; genetic analysis and QTL mapping of germination traits; seed ageing and ethylene production; recent accomplishments in seed enhancement research and application of nanotechnology. Modern techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fingerprinting and other molecular techniques and their utilization; techniques for improving seed quality; proteomic analysis; seed priming, coating, pelleting and synthetic seeds; GM seeds and their detection, terminator technology (GURT). Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

Practical

Advanced techniques on seed science research, seed genetic purity testing by various biochemical and molecular markers, Testing of GM seeds. Demonstration of ELISA and PCR techniques. Production of synthetic seeds, seed encapulation. Visit to the R&D units of seed genetic purity testing etc.

SERICULTURE

Course No.	Title	Credits
SER 601	Advances in Genetics and Breeding of Mulberry	1+1
SER 602	Physiology and Nutrition of Mulberry	1+1
SER 603	Physiology and Nutrition of Silkworms	1+1
SER 604	Physiological and Biochemical Genetics in Silkworm	1+1
SER 605	Viral and Bacterial Diseases of Silkworms	1+1
SER 606	Protozoan and Fungal Diseases of Silkworms	1+1
SER 607	Integrated Pest Management in Sericulture	1+1
SER 608	Advances in Silk Technology	1+1
SER 609	Seri-Business Management	1+0
SER 610	Sericulture Biotechnology	1+1
SER 671	Qualifying Examination	3
SER 681	Seminar	4
SER 691	Research	38

SER 601 ***Advances in Genetics and Breeding of Mulberry*** **(1+1)**

Theory

Origin and exploitation of the genus *Morus*. Mulberry species and their distribution in India and abroad. A critical appraisal of taxonomy of the genus *Morus*. Recent advances in cytology of mulberry. Karyomorphological studies, mitotic and meiotic studies. Recent advances in embryological studies of mulberry. Recent advances in conventional methods of breeding. Conservation and maintenance of mulberry germplasm. Role of mulberry germplasm in crop improvement. Evolution of mulberry genotypes for different growth and yield parameters. Mutation breeding and ploidy breeding in mulberry improvement. Evaluation of mulberry germplasm for stress. Evaluation of germplasm for leaf quality and resistance to

pests and diseases. Recent advances in application of plant tissue culture and biotechnology for the improvement of mulberry. Statistical approach for yield tests in mulberry.

Practical

Distribution of the genus *Morus*, its geographic spread using maps; Endemism in mulberry. Germplasm, its importance in plant improvement, Evaluation of existing collections with the Department. Categorization of collections available using standard key provided by CSB. Visit to CSB germplasm unit, Hosur. Studies on maintenance and supply of planting material in mulberry. (Gene bank). Operation of growth and yield parameters in mulberry for varietal differences. Plant tissue culture in mulberry. Hands on training in callusing, sub-culturing. Root initiation, shoot initiation and hardening of tissue culture plants, Triploids etc., Active bud treatment for polyploid induction in mulberry. Selective breeding using marker assisted selection for identifying WUE mulberry genotypes.

SER 602 *Physiology and Nutrition of Mulberry* (1+1)

Theory

Physiological aspects of mulberry. Factors affecting sprouting and establishment of cuttings, role of hormones in bud sprouting and rooting of cuttings and other physical agents like temperature and water. Growth and development, leaf area development, duration of vegetative period. Photoperiodism and thermoperiodism. Plant growth hormones and growth regulators – nature, biosynthesis and functions. Photosynthesis and productivity, respiration, transpiration, flowering, fruit set and seed development. Dormancy and viability of buds and seeds. Physiology of abiotic and biotic stress. Forms of mineral elements absorbed by mulberry, mobility status of various nutrients and soil fertility status INM principles. Visual symptoms of nutritional disorders, key to symptoms of nutritional disorders. Macro and micro nutrients – their requirement, role, deficiency symptoms and remedies. Organic manures for nutrient management in mulberry.

Practical

Study of sprouting and rooting in mulberry. Use of growth hormones, rates of transpiration and photosynthesis. Determination of the factors governing leaf area development. Mineral nutrients – deficiency symptoms, seed viability. Host plant leaf analysis for biochemical and mineral composition.

SER 603 *Physiology and Nutrition of Silkworms* (1+1)

Theory

Importance of understanding physiological processes. Physiology of digestion, circulation, respiration and excretion. Mechanism of impulse conduction, Reproductive physiology and physiology of egg diapause. Endocrine organs-their secretion and role in silkworm growth and development. Molecular basis for hormonal regulation with special reference to PTTH and ecdysone hormone biosynthesis. Physiology of silk secretion and regulation of silk protein biosynthesis. Pheromones in silkworms and their role in regulating silkworm behaviour. Utilization of mulberry leaves by the mulberry silkworm, Nutritional requirements of silkworm, Digestion and utilization of various nutrients by silkworm, Digestive enzymes. Metabolism of various kinds of nutrients-carbohydrates, proteins and amino acids, vitamins and minerals. Artificial diets for silkworm.

Practical

Study of consumption indices, estimation of carbohydrates, proteins and lipids in various tissues of silkworm/silkmoth. Use of hormones in controlling growth and silk production. Plant products influencing growth and productivity of silkworm. Preparation of artificial diets for silkworm. Nutrient supplementation influencing growth and development of silkworm.

SER 604 *Physiological and Biochemical Genetics in Silkworm* (1+1)

Theory

Developmental genetics; embryonic development of non-hibernating and hibernating eggs; parthenogenesis; development of

embryos under special genetic conditions, i.e., controlled by E-gene group, NC gene, NI-gene, etc., physiological genetics. Induction and translocation of quantitative and qualitative traits in silkworms. Genetic control of hormonal mechanism. Inheritance of moultinism, voltinsim and juvenility. Role of voltinism genes on determination of quantitative characters. Quantitative traits affected by maturity, genes-influence of environmental conditions on the expression of quantitative character. Maternal inheritance and its biochemical aspects. Genetic analysis of cocoon colours; physiology of pigments, genetic relation in terms of pigment permeability and transmission. Biochemical genetics; genetic basis of enzymes – amylase – esterase – alkaline phosphatase – acid phosphatase – proteins and blood cells – haemocytes – silk protein – glutinous protein of the mucous gland. Importance of developmental, physiological and biochemical genetics in silkworm management, nutrition and breeding.

Practical

Status of Non-Diapausing eggs embryonic development, Diapausing eggs embryonic development, Artificial production of parthenogenesis, Inheritance of moultinisum, Inheritance of voltinisum, Inheritance of juvenility, Environmental influence on expression of quantitative traits, Maternal inheritance of characters, Genetic analysis of cocoon colours, Genetic analysis of pigments, Study of enzymes, Study of proteins, Blood cells, Silk protein estimation, Silkworm nutrition, Preparation of artificial diet, Rearing performance of silkworm on the artificial diet.

SER 605 ***Viral and Bacterial Diseases of Silkworms*** **(1+1)**

Theory

Introduction, economic importance, classification of silkworm viruses. Symptomotology and diagnosis of viral infections of silkworm. Purification of viruses and serological techniques. Nature, size and morphology of grasserie virus, cytoplasmic virus, infectious flacherie virus, densonucleosis virus, mid gut nuclear polyhedrosis virus, etc., predisposing factors, disease cycle including replications, other hosts and spread of virus diseases. Interaction among silkworm

viruses. Prevention and control of viral infections. Introduction, history and importance of bacterial diseases of the silkworm. Mixed infections. Etiology of bacterial flacherie, morphology and chemistry, pathogenicity, route of infection, silkworm immunity, mixed infections, serological detection. Introduction, history and importance of bacterial toxicosis of the silkworm. Structure and chemistry, biosynthisis of protein crystal. Morphology of sporulation and chemistry of crystal toxin, histopathology, pathophysiology, prevention and control.

Practical

Survey on viral and bacterial diseases of silkworm, diagnosis of viral, bacterial and mixed infections of silkworm. Purification methods, Serological techniques. Infectivity techniques. Study of symptomatology, structure and morphology of polyhedral viruses and bacteria, staining techniques for different occluded viruses, predisposing factors, Histopathology, Replication cycles. Cross infectivity, prevention and control of viral and bacterial pathogens. Survey of pathogenic bacteria in silkworm body, culturing methods staining for *Bacillus thuringiensis*, Study of dispersal methods, Histopathology, Chemotherapy prevention and control.

SER 606 ***Protozoan and Fungal Diseases of Silkworms*** **(1+1)**

Theory

Introduction, history and importance of the pathogenic protozoa of silkworms. Isolation, purification, biodiversity, morphology and chemistry. Strains of Microsporadians infecting silkworms and their life-cycle. Symptoms at the various stages of the life cycle of silkworm, pathologies, route of infection, alternative hosts, cross infectivity, survival and spread, detection, prevention and control. Economic importance of fungal diseases of silkworms, general morphology of deuteromycetes. Life cycle of the different fungi, pathogenic to silkworms white, green, yellow, black and red muscardines and *Aspergillus* diseases. Symptomotology, pathology, host range, host susceptibility, prevention and control.

Practical

Isolation and purification of pathogenic protozoa and fungi. Survey of pathogenic protozoa and fungi in silkworm body. Infectivity techniques. Symptomatology. Histopathology and histochemistry. Cross infectivity studies. Host range. Study of dispersal methods. Examination for microsporadians. *In-vitro / in-vivo* evaluation of chemicals/botanicals against the pathogenic protozoa and fungi. Prevention and control.

SER 607 ***Integrated Pest Management in Sericulture*** **(1+1)**

Theory

Pest - classification of insect pests. Types of damage to host plants of silkworm by pests. Causes for insects assuming pest status and factors affecting the natural balance under mulberry ecosystem. Pest surveillance and forecasting of pest outbreak. Assessment of damage caused by insect pests. Pest management – principles and methods. Bio-ecology and integrated management of root feeding, stem boring, leaf feeding, sap sucking pests of mulberry. Bio-ecology & integrated management of uzi fly. Bio-ecology and integrated management of pests of host plants of non-mulberry silkworms. Bio-ecology and integrated management of pests of non-mulberry silkworms. Pests of grainages and their management. Eco-friendly pest management practices.

Practical

Insect pests and their classification. Types of damage to host plants of silkworms by pests. Causes for insects assuming pest status. Pest surveillance and forecasting of pest outbreak. Assessment of insect population. Estimation of damage caused by insect pests to crops. Pest management: principles and methods. Estimation of the incidence of termites among different varieties of mulberry. Estimation of the incidence of tukra, spiraling white fly, thrips, Bihar hairy caterpillar, leaf roller and mite species on different varieties of mulberry. Integrated management of root knot nematode of mulberry. Estimation of the incidence of uzi fly in silkworm crops and Integrated management. Insect and non-insect pests associated with silk moth egg production centres (Grainages). Pests of host plants of non-mulberry silkworms. Forms, formulations

and application of pesticides. List of commonly used pesticides and related useful information. Visit to Seri-agro-ecosystems (farmer's field). Visit to R & D Institutes of Sericulture.

SER 608 ***Advances in Silk Technology*** **(1+1)**

Theory

Commercial characteristics of non-mulberry silk cocoons. Reeling technology for non-mulberry silks viz., stifling and cooking methods, spinning of silk, various equipments for reeling and spinning of non-mulberry silks. By-products of non-mulberry silk industry and their utilization. Various steps involved in spun silk industry and pupa oil mill. Economics of silk reeling / spinning. Organization of silk reeling establishments. Reeling industries / units – overview, energy / wood / fuel consumption – release of smoke, constituents of smoke – effect of smoke on human health and rearing environment. Effluents from silk production. Solid waste, dust, smoke and effluents from silk weaving factory and spun silk mills. Effect of these on ecosystem. Occupational health risk on reelers / workers – skin and lungs related problems. Policies on pollution control programmes on health hazards – risk and proposed options.

Practical

Study of biodiversity of non-mulberry silk fauna. Organizational setup for marketing of non- mulberry silk cocoons, grading of non-mulberry cocoons (Tasar) based on size and colour, stifling methods, cooking methods reeling machinery, by-products of non-mulberry sericulture industries, Estimation of silk productivities, Spun silk production, visit to spun silk mills.

SER 609 ***Seri-business Management*** **(1+0)**

Theory

Sericulture as an industry – overview, concept and principles of management, personal and resource management. Silkworm seed production management – organization set up, selection of sites, establishment of grainage, production planning, raw material, manpower, seed storage, programme, marketing, record maintenance; case studies. Leaf production and supply

management, synchronized rearing programme – manpower, community rearing, house management, marketing of cocoons. Reeling unit management – organization set up, raw materials like cocoons, fuel, water, etc. Manpower, procurement skills – constraints, marketing – case studies of charka, cottage basin and filature, management of byproducts of sericulture – risk management / non-cash input management.

SER 610 ***Sericulture Biotechnology*** **(1+1)**

Theory

Perspective, scope and current status of biotechnology, techniques adopted, RFLP (restricted fragment length polymorphism), AFLP (Amplified fragment length polymorphism) and PCR (Polymerase chain reaction), mapping and sequencing of silkworm genome, molecular basis for improvement of yield components of silkworm races. Role of agents and microorganisms with emphasis to common vectors for gene transfer, silk gland genetics, germline transformation and scope of genetic manipulation between silkworm breeds. Molecular biology and tissue culture in respect of host plants of silkworms, gene expression and study of single gene copy and multiples of genes, somatic cell genetics, recombinant DNA technology and its use. Application of site directed mutagenesis, gene targeting and gene therapy. Stability and expression of transferred genes in host plants of silkworms. Application of molecular techniques in gene identification for further breeding programmes.

Practical

RFLP marker technique as applied to mulberry crop and silkworm improvement programmes; equipments and chemicals used in RFLP, RAPD and PCR techniques; hands on training in DNA extraction isolation, purification and concentration. Agarose GEL electrophoresis; DNA qualification; Quality assessment of DNA; DNA fragment separation; PCR reaction; PCR amplification; GEL images and analysis; Estimation of Genetics distances; Cluster analysis; Visit to Seribiotech. Lab. of CSB at Kodathi; visit to MAS lab and Biotechnology lab of UAS(B); visit to CSR&TI, Mysore-Biotechnology division.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Course No.	Title	Credits
SAC 601	Instrumental Methods of Analysis	1+1
SAC 602	Tracer Techniques in Soil and Plant Studies	1+1
SAC 603	Remote Sensing and GIS Techniques for Soil and Crop Studies	1+1
SAC 604	Advances in Soil Mineralogy	1+1
SAC 605	Advances in Soil Genesis and Micropedology	1+1
SAC 606	Advances in Soil Physics	1+1
SAC 607	Physical Chemistry of Soils	1+1
SAC 608	Chemistry of Submerged Soil	1+1
SAC 609	Advances in Soil Biochemistry	1+1
SAC 610	Advances in Soil Fertility	1+1
SAC 611	Land Use Planning and Watershed Management	1+1
SAC 612	Advances in Agricultural Chemicals	1+1
SAC 613	Recycling of Organic Resources and Management	1+1
SAC 614	System Approaches in Soil and Crop Studies	1+1
SAC 671	Qualifying Examination	3
SAC 681	Seminar	4
SAC 691	Research	38

SAC 601 ***Instrumental Methods of Analysis*** **(1+1)**

Theory

Theory and application of physicochemical methods used in analytical chemistry. Electrochemical methods- Potentiometry, pH measurements, potentiometric titration. Conductometry : Conductivity measurements, conductometric titrations. Optical methods- Nature of electromagnetic radiation, interaction of EMR with matter, Beer-Lamberts Law, spectrometry, nephelometry, turbidometry, flame photometry/ Atomic absorption spectroscopy.

ICP, Mass spectroscopy Principles and applications of X- ray diffraction. Polarimetry – optical activity, dextro and levo rotation and specific rotation. Extraction methods- Partitoning, distribution ratio,single extraction, multiple extraction and counter current extraction. Chromatography - classification of chromatographic techniques, partition chromatography, adsorption chromatography and gas chromatography and high performance liquid chromatography. Use of electron microscopy and its application in agriculture.

Practical

Electrochemical methods – pH meters, potentiometric titrations, conductivity bridge and conductometric titration. Optical methods- colorimeters, spectrometers, nepholometers, turbidometers, flame photometers, atomic absorption spectrophotometer, ICPS, Polarimety - Optical activity, dextro and levo rotation, specific rotation. Chromatography – Thin layer chromatography, gas chromatography and HPLC. Electron microscope and use in clay mineralogy. Visit to important local laboratories like IISc, IIHR, IRC and ISRO

SAC 602 ***Tracer Techniques in Soil and Plant Studies*** **(1+1)**

Theory

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter. Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography Isotopic dilution techniques used in soil and plant research; use of stable isotopes; principles and use of mass spectrometer; application of isotopes in studies on organic matter, nutrient transformations, rooting pattern and fertilizer use efficiency; carbon dating Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes.

Practical

Storage and handling of radioactive materials, Determination of half life and decay constant, Preparation of soil and plant samples for radioactive measurements, Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes, Determination of A, E and L values of soil using 32P/ 65Zn, Use of neutron probe for moisture determination, Sample preparation and measurement of 15N enrichment by mass spectrophotometery / emission spectrometry

SAC 603 ***Remote Sensing and GIS Techniques for Soil and Crop Studies*** **(1+1)**

Theory

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter. Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations. Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management. Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evaluation of soil variability. Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of data files in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

SAC 604 ***Advances in Soil Mineralogy*** **(1+1)**

Theory

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism. Surface chemistry of clays. Genesis of clays, structure of clay minerals, classification and nomenclature of clay silicates. Physico-chemical properties of clay minerals and their importance in agriculture. Methods of identifying clay minerals.

Practical

Sample selection - clay separation – pretreatment of soil for clay separation – removal of soluble salts, carbonates, organic matter, free iron oxide, particle size separation. Preparation of clay for X ray, DTA, IR, electron microscope Interpretation of X ray diffractogram. DTA curves, IR Charts, Electron microscope, photographs, calculation of layer charges. Elemental analysis, Surface area calculation from elemental analysis data.

SAC 605 ***Advances in Soil Genesis and Micropedology*** **(1+1)**

Theory

Pedogenic evolution of soils; soil composition and characterization. Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals. Assessment of soil profile development by mineralogical and chemical analysis. Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Practical

Morphological description of soil profiles, separation of clay from soil, total chemical analysis of clay and non clay fractions. Identification of clay and sand minerals. Physical and chemical determination of whole soil fractions. Derivation of weathering indices and evaluation of soil profile by mineralogical and chemical analysis. Preparation of macro and micro monoliths, Preparation of polished block. Soil fabric and matric analysis. Staffling techniques. Quantification and interpretation of micropedological features.

SAC 606 ***Advances in Soil Physics*** **(1+1)**

Theory

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system. Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow. Theories of horizontal and vertical infiltration under different boundary conditions. Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves. Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil. Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soil conditioners - types, characteristics, working principles, significance in agriculture. Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Practical

Kinds of thermometers used in soils- calibration of thermometer, heat capacity and specific heat. Heat transfer, air permeability, apparent diffusion coefficient. Determination of oxygen diffusion rate. Hysteresis.

SAC 607 ***Physical Chemistry of Soils*** **(1+1)**

Theory

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

approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer. Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction. Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system). Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Practical

Extraction of total constituents in soils, Determination of buffering capacity of soil, Determination of cation exchange and anion exchange, Determination of adsorption of isotherms, Determination of quantity and intensity of potassium, Determination of phosphate potentials in soils, Calculation of layer charges.

SAC 608 ***Chemistry of Submerged Soil*** **(1+1)**

Theory

Characteristics of submerged soils, physicochemical and biological characteristics of submerged soils. Electro chemical changes during soil submergence. Transformation of inorganic and organic constituents under submerged conditions. Oxidation reduction reaction, redox potentials, fertility evaluation of submerged soils. Accumulation of toxic elements, problem and management of submerged soils including elements, fluffy paddy soils. Effect of submergence on global warming.

Practical

Simulation of submerged condition in the field. In-situ measurement of pH, redox potential, EC and other electrochemical properties of flooded water, soil leachate. Studies on transformation and availability of plant nutrients in flood water, soil and leachate.

SAC 609 ***Advances in Soil Biochemistry*** **(1+1)**

Theory

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools. Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids. Nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils. Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes. Humus - pesticide interactions in soil, mechanisms.

Practical

Extraction of soil carbohydrates. Estimation of organic phosphate and sulphate in soils. Analysis for different fractions of nitrogen in soils. Studies on sulphur mineralisation and sulphur oxidation in soils. Extraction and estimation of humic and fulvic acids from soils. Spectral characteristics of humic acids. Estimation of humic acid carbon, total acidity, carboxylic and phenolic contents in humic acids. Decomposition rate of organic matter

SAC 610 ***Advances in Soil Fertility*** **(1+1)**

Theory

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices. Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils. Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils. Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting. Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-

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

Practical

Soil testing methods for nutrients, Fertliser recommendations for crops by soil testing, STCR approach, DRIS, Biochemical changes in plants under nutrient deficiency levels. Site specific nutrient management. Integrated nutrient management

SAC 611 ***Land Use Planning and Watershed Management*** **(1+1)**

Theory

Concept and techniques of land use planning; factors governing present land use. Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application. Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity. Watershed development/management-concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Practical

Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index, Land capability classification, Fertility capability classification, Irrigability classification, Visits to a watersheds

SAC 612 ***Advances in Agricultural Chemicals*** **(1+1)**

Theory

Agricultural chemicals – Historical background in the use of plant protection chemicals. Production and consumption of agricultural chemicals in Karnataka and India, Insecticides - classification based on chemical composition and mode of action along with examples. Insecticides – structure, properties and mode of action of inorganic insecticides - arsenicals and fluoride compounds, of botanical insecticides of nicotinoids, rotenoids, pyrethroids and azadiractinoids and their analogues and organic insecticides of organochlorine, organophosphorus and carbamates compounds. Fungicides - classification of fungicides, structure, methods of preparation, properties, mode of action of copper, sulphur, mercury, and other inorganic and organic fungicides - systematic fungicides & newer classes of fungicides like benzimidazoles, oxathins, piperazine, imidazole and triazole. Herbicides – classification, structure, properties, mode of action of inorganic and organic herbicides like phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas. Rodenticides, fumigants, acaricides, nematicides and sterilents – definition, characteristics, structure, properties, mode of action and uses. Pesticide formulations - insecticide residues and problems, Soil pesticides interaction, adsorption, pesticide degradation, pollution hazards, safety measures, tolerance limits in food crops, soil water bodies. Pollution hazards by pesticides, tolerance limits in food and forage. Effects of pesticides on soil fertility and plant growth and non-target microflora. Adulteration of pesticides – regulatory agencies like BIS/ FAO/ WHO.

Practical

BIS standards for commonly used pesticides. Extraction procedures for pesticide residues from soil and plant samples. Cleanup procedures for pesticide residues from soil and plant samples. Spectrophotometric, GC, HPLC in Pesticide formulation/ residue analysis. Studies on Bioassay techniques for Persistence of herbicides. Studies on adsorption of Pesticide in soil. Studies on Persistence of Pesticide residues in soil. Studies on Persistence of Pesticide residues in crops

SAC 613 ***Recycling of Organic Resources and Management*** **(1+1)**

Theory

Organic resources – definition, classification, characteristics, composition, criteria for recycling of organic resources, Major degradation pathways of organic resources. Soil organic matter pools, mineralisation. Composting – history, definition, objectives, essentials, technologies, types, advantages and limitations. Biochemical changes during decomposition, relationship between ligninun,cellulose, poly phenols and other constituents, factors influencing composting, quality standard of compost. Agro-industrial organic resources – characteristics and bioconversion technologies. Crop residue management, Vermitechnology, Biofertilizers – influence on soil and plant growth. Sewage treatment, sludge chemistry, uses and after effects, Integrate nutrient management, organic farming, biodynamic farming – salient features and utility.

Practical

Recent technique in compost making and enriched compost. Visit to biogas and sewage and compost plants - acquaint with techniques adopted. Collection of raw materials, biogas spent slurry, sludge and compost. Manurial constituent analysis of different organic resources

SAC 614 ***System Approaches in Soil and Crop Studies*** **(1+1)**

Theory

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study. Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and validation, calibration; representation of continuous systems simulation models - procedural and declarative. Simulation - meaning and threats; simulation experiment, its design and analysis. Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under

different soil, water, nutrient, climatic and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

Use of flow chart or pseudo-code in the program writing. Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic). Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion.