# AGRICULTURAL ECONOMICS

## Course Structure

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## SERVICE COURSE

| FOR 510         | ECONOMICS OF AGROFORESTRY SYSTEMS                             | 2+1     | II  |

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

Minor subject both for Master's and Doctoral programme: Statistics

To be taught by: 1 Agricultural Economics; 2 Computer Section
AGRICULTURAL ECONOMICS

Course Contents

AG ECON 501  MICRO ECONOMIC THEORY AND APPLICATIONS  2+0  SEM - I

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

Theory
UNIT-II: Theory of Production - Production functions Returns to scale and economies of scale Technical progress Theory of Costs Cost curves Profit maximization and cost minimization - Derivation of supply curve Law of Supply - Producers'surplus.

Suggested Readings

AG ECON 502  MACRO ECONOMIC THEORY  2+0  SEM - I

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

Theory
UNIT-II: Consumption function- Investment and savings - Concept of Multiplier and Accelerator - Output and Employment - Rate of interest - Classical, Neo classical and Keynesian version- Classical theory Vs Keynesian theory - Unemployment and Full employment.
UNIT-IV: IS & LM frame work - General Equilibrium of product and money markets - Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy.
UNIT-V: Business/Trade cycles Its meaning, phases, characteristics and types, Concepts of economic growth models.

Suggested Readings
AG ECON 503  EVOLUTION OF ECONOMIC THOUGHT  1+0  SEM - II

Objective

To introduce the students to the evolution of economic thought over a period of time, the background of emanation of thoughts and approaches, as acts of balancing and counter balancing events and criticisms. The course will also in a comprehensive way help the students to know and appreciate the contributions of the Galaxy of Economists.

Theory

UNIT-IV: The Era of globalization Î– Experiences of developing world - Rigidity of the past vs. emerging realism Î– The changing path of international Institutions to economic growth and development approaches.
UNIT-V: Economic Thought in India Î– Naoroji and Gokhale Î– Gandhian Economics - Economic thought of independent India Î– Nehruâ€’s economic philosophy - Experiences of the Structural adjustment programmes of the post liberalization era.

Suggested Readings


AG ECON 504  FARM MANAGEMENT AND AGRICULTURAL PRODUCTION ECONOMICS  2+1  SEM - I

Objective

To expose the students to the basic concepts, significance, uses and application of principles of farm management/agricultural production economics.

Theory

UNIT-II: Factors of production, classification, interdependence, and factor substitution - Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.
Practical
Different forms of production functions - specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap - incorporation of technology in production functions- measuring returns to scale-risk analysis through linear programming.

Suggested Readings
Heady EO. Economics of Agricultural Production and Resource Use. Prentice-Hall.

AG ECON 505 AGRICULTURAL MARKETING AND PRICE ANALYSIS 2+1 SEM - I

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

Theory
UNIT-IV: Role of Information Technology and telecommunication in marketing of agricultural commodities, identifying market opportunities through marketing information systems and research Ð market information service-elements of the information systems-sources of global information-market research-special problems in international market research..

Practical
Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Performance analysis of Regulated market and marketing societies. Market Intelligence Ð Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports Ð commodity outlook - Technical Analysis for important agricultural commodities - Fundamental Analysis for important agricultural commodities - Presentation of the survey results and wrap-up discussion.

Suggested Readings
AG ECON 506  RESEARCH METHODOLOGY FOR SOCIAL SCIENCES

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

Theory
UNIT-I: Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem - research prioritization - selection of research problem. Approach to research - research process.
UNIT-II: Hypothesis - meaning - characteristics - types of hypothesis - review of literature - setting of Course Objective and hypotheses - testing of hypothesis.
UNIT-III: Sampling theory and sampling design - sampling error - methods of sampling - probability and non-probability sampling methods - criteria to choose. Project proposals - contents and scope - different types of projects to meet different needs - trade-off between scope and cost of the study. Research design and techniques - Types of research design.

Practical

Suggested Readings

AG ECON 507  PRINCIPLES OF ECONOMETRICS

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

Theory
UNIT-I: Introduction - relationship between economic theory, mathematical economics and econometrics, methodology of econometrics-regression analysis.
UNIT-II: Basic two variable regression - assumptions estimation and interpretation- approaches to estimation - OLS, MLE and their properties - extensions to multi variable models-multiple regression estimation and interpretation.

UNIT-III: Violation of assumptions - identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation - data problems and remedial approaches - model misspecification.

UNIT-IV: Use of dummy variables-limited dependent variables - specification, estimation and interpretation.

UNIT-V: Simultaneous equation models - structural equations - reduced form equations - identification and approaches to estimation.

Practical

AG ECON 508

Objective

The objective of this course is to impart knowledge of Linear programming techniques.

Theory

UNIT-I: Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UNIT-II: Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions.

UNIT-III: Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

UNIT-IV: Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programme.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings


AG ECON 509  AGRICULTURAL FINANCE AND 2+1 SEM – II
PROJECT MANAGEMENT

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

Theory
UNIT-I: Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending - Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

UNIT-II: Lending to farmers - The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions - credit widening and credit deepening.


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

Suggested Readings

AG ECON 510/ SEED MARKETING AND MANAGEMENT 2+1 SEM - II
SST 514

Objective
To train the students regarding economic concepts of seed marketing in India and role of Government in development of efficient seed marketing system.
Theory

UNIT-I: Basic concepts of agricultural marketing, seed marketing, importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector.
UNIT-II: Demand and supply of seed, cost of production and returns and factors determining seed needs, pricing policies: seed pricing and price policies, seed processing and packing/packaging.
UNIT-III: Purpose and approaches to seed marketing; Seed marketing mix, sales promotion, distribution channels, marketing costs and margins. Market research, information and segmentation.
UNIT-IV: Policy environment for sustainable growth of Seed sector in India. Salient features of proposed seed act and national seed policy, role of government in efficient seed marketing: quality control and assurance. WTO and Seed industry in India.

Practical

Estimation of cost of seed production, marketing costs and margins of seeds of different crops. Estimation of seed demand and supply, seed forecasting techniques, marketing plan.

Suggested Readings


AG ECON 511 INTERNATIONAL ECONOMICS 1+1 SEM - I

Objective

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

Theory

UNIT-II: Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case.
UNIT-III: Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model - Trade Creation and Trade Diversion ï– Offer Curve - Export Supply Elasticity and Import Demand Elasticity - Comparative Advantage and Absolute Advantage.
UNIT-IV: Official Exchange Rate and Shadow Exchange Rate - Walras Law and Terms of Trade ï– Trade Blocks.

Practical


Suggested Readings

Theory

UNIT-I: Old and New Institutional Economics - Institutional Economics Vs Neo-classical Economics. Definition of institutions ï Distinction between institutions and organizations - Institutional evolution
UNIT-IV: Economic analysis of property rights- property rights regimes ï private property ï State Property - Common property Resources (CPRs) ï public goods and club goods.
UNIT-V: Special features of institutional arrangements in agriculture ï Transaction costs in agriculture - Case Studies - Theories of agrarian institutions - tenancy institutions.

Suggested Readings

AG ECON 513 AGRICULTURAL DEVELOPMENT AND POLICIES 2+0 SEM - 1

Objectives
- To provide orientation to the students regarding the concepts and measures of economic development
- To provide orientation on theories of economic growth and relevance of theories in developing countries.
- To make them to understand the agricultural policies and its effect on sustainable agricultural development
- To make them to understand the globalization and its impact on agricultural development.

Theory
UNIT-II: Economic development - meaning, stages of economic development, determinants of economic growth, Optimal Economic Growth – Recent Experiences of developing country economies in transition – Role of state in economic development – Government measures to promote economic development. Introduction to development planning.
UNIT-IV: Development issues, poverty, inequality, unemployment and environmental degradation – Models of Agricultural Development – Induced Innovation Model - policy options for sustainable agricultural development.


Suggested Readings

AG ECON 514 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS

Objectives
- To introduce economics principles related to natural resource and environmental economics
- To explore the concept of efficiency and the efficient allocation of natural resources
- To understand the economics of why environmental problems occur.
- To explore the concept of efficiency and the efficient allocation of pollution control and pollution prevention decisions.
- To understand the environmental policy issues and alternative instruments of environmental policies

Theory
UNIT-II: Theory of optimal extraction renewable resources – economic models of oil extraction- efficiency - time path of prices and extraction - Hotelling’s rule, Solow-Harwick’s Rule. Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.
UNIT-IV: Environmental perspectives - biocentrism, sustainability, anthropocentrism - Environmental problems and quality of environment - Sources and types of pollution - air, water, solid waste, land degradation – environmental and economic impacts - Economics of pollution control - efficient reduction in environmental pollution.
UNIT-V: Environmental regulation – economic instruments - pollution charges - Pigovian tax - tradable permits – indirect instruments - environmental legislations in India.
Practical


Suggested Readings


Hartwick JM & Olewiler ND. 1998. The Economics of Natural Resource Use. 2nd Ed. Addison-Wesley Educational Publ.


AG ECON 515 INTELLECTUAL PROPERTY MANAGEMENT

Objective

The objective of this course is to create awareness about intellectual property rights in agriculture. The course deals with management of patents, trademark, geographical indications, copy rights, designs, plant variety protection and bio-diversity protection. The students will be taught on the Marketing and Commercialization of Intellectual Properties.

Theory


UNIT-II: Discovery versus Invention - Patentability of Biological Inventions - Method of Agriculture and Horticulture - procedure for patent protection: Preparatory work. Record keeping, writing a patent document, filing the patent document -Types of patent application-patent application under the Patent cooperation treaty (PCT).


UNIT-V: Procedures for commercialization of technology - Valuation, Costs and Pricing of Technology- Licensing and implementation of Intellectual Properties - Procedures for commercialization - Exclusive and non exclusive marketing rights- Research Exemption and benefit sharing .
Suggested Readings

AG ECON 516/ COMP 501
COMPUTER PROGRAMMING IN STATISTICAL RESEARCH
2+1 SEM - I, II
(To be taught by Computer Section)

Theory
UNIT I: Introduction to Computers, Types of Computers , Computer generations and classifications , Computer peripherals , Memory units, Control units, Arithmetic and Logic unit, Secondary storage. Computer codes and Arithmetic; Binary system , Octal and Hexadecimal number system, Conversion to decimal system.
UNIT II: Computer softwares Î Machine language , Assembly language , high level language , Compilers , Interpreters and System utilities, Flowcharting and programming , Debugging , testing and Types of errors.
UNIT III: Formulation of Algorithm, Elements of FORTRAN language, constants and variables, Operations and symbols, Expressions, Common mathematical functions.
UNIT IV: Arithmetic assignment statement, Input, Output and FORMAT statements, termination statements, GO TO, Computed GO TO, Arithmetic IF and Logical IF statements, Type statement, Complex and Logical variables, DOUBLE PRECISION variables.
UNIT V: Subscribed variables, Dimension statement, DO statement, Statement function; FUNCTION and SUBROUTINE subprogram, EQUIVALENCE , COMMON and DATA statements.

Practical
Development of computer programs in FORTRAN for the measures of central tendency, measures of dispersion, correlation and regression , simple testing of significance and analysis of CRD and RBD.

Suggested Readings
Rajaraman V. Computer Programming in FORTRAN.
Ram Kumar. Programming in FORTRAN-77.
Sharma KD. Programming in FORTRAN.

AG ECON 517
RURAL MARKETING
2+0 SEM - I

Objective
To provide understanding regarding issues in rural markets like marketing environment, consumer behaviour, distribution channels, marketing strategies, etc.

Theory
UNIT-I: Concept and scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India.
UNIT-II: Environmental factors - socio-cultural, economic and other environmental factors affecting rural marketing.
UNIT-III: Rural consumer behaviour - behavior of rural consumers and farmers; buyer characteristics and buying behaviour; Rural vs urban markets.
UNIT-IV: Rural marketing strategy - Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; product mix, pricing Course Objective, pricing policy and pricing strategy.
UNIT-V: Product promotion - Media planning, planning of distribution channels, and organizing personal selling in rural market in India.

Suggested Readings

AG ECON 518
COMMODITY FUTURES TRADING
2+0 SEM - II

Objective
This course is aimed at providing the basic understanding and the mechanics and value of futures markets for speculators and hedgers who in turn will serve as price risk management activities of agribusiness firms.
Theory


UNIT-II: Transaction and settlement - delivery mechanism - role of different agents - trading strategies - potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

UNIT-III: Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

UNIT-IV: Important global and Indian commodity exchanges - contracts traded - special features - Regulation of Indian commodity exchanges - FMC and its role.

UNIT-V: Fundamental Vs Technical analysis - construction and interpretation of charts and chart patterns for analyzing the market trend - Market indicators - back testing. Introduction to technical analysis software - analyzing trading pattern of different commodity groups.

Suggested Readings


AG ECON 601 ADVANCED MICRO-ECONOMIC 1+1 SEM - II ANALYSIS

Objective

The objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization, expenditure minimization, constrained profit maximization, and cost and expenditure minimization. These mathematical structures form the basic building blocks of neoclassical economics; this course will stress the development and application of these important models. We follow a calculus rather than a graphical approach to the theory. In the subsequent sections of the course, we provide a fairly rigorous exposure to price determination under different market situations, general equilibrium theory, causes and consequences of market failure and welfare economics including the theory of public choice.

Theory


Practical


Suggested Readings


AG ECON 602 ADVANCED MACRO-ECONOMIC 2+0 SEM - II ANALYSIS

Objectives

Advanced macroeconomics course will be offered to Ph.D. students of Agricultural Economics with the following Course Objective

- to understand the macroeconomic theory
- to examine the macroeconomic Policy issues
- to analyze the macroeconomic Policy implications.

Theory

UNIT-I: Review of Macro Economics concepts-Comparative statistics- Keynesian theory-Consumption Function and Theories of Consumption -Saving Function and Theories of Saving.


Suggested Readings


AG ECON 603 ADVANCED ECONOMETRICS 2+1 SEM - II

Objective

The objective of this course is to impart knowledge on advanced econometric tools to the Research Scholars of agricultural economics. Training in advanced econometrics will help the Research Scholars to analyse the economic problem by applying quantitative techniques.
Theory

UNIT-I: Review of classical regression model - review of hypothesis testing - restrictions on parameters - single equation techniques.

UNIT-II: Ordinary least squares - weighted least squares - generalized least squares - method of principal components - instrumental variables method - maximum likelihood method - errors in variables, non-linearity and specification tests - non spherical error terms.

UNIT-III: Dummy variables - Qualitative and truncated dependent variables - limited dependent variables - LPM, probit and logit models, their multinomial extensions.

UNIT-IV: Autoregressive distributed lag models - panel data fixed and random effects models and their extensions.

UNIT-V: Simultaneous equation methods - identification - estimation by indirect least squares 2SLS, SURE, 3SLS.

Practical


Suggested Readings


AG ECON 604 ADVANCED PRODUCTION ECONOMICS 2+1 SEM - I

Objective

To expose the students to the concept, significance and uses of advance production economics.
Practical
Estimation of different forms of production functions - Optimal input and product choice from estimated functions - Derivation of demand and supply functions and estimation - Estimation of cost function and interpretations - Optimal product and input choice under multi input and output system - Estimation of factor shares from empirical functions estimated - Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology - Estimation of efficiency measures - Stochastic, probabilistic and deterministic frontier production functions - Risk programming - MOTAD - Quadratic programming - Simulation models for agricultural production decisions - Goal programming - Weighted, lexicographic and fuzzy goal programming - Compromise programming.

Suggested Readings

**AG ECON 605 QUANTITATIVE DEVELOPMENT 1+1 SEM - I**

**PATTERN ANALYSIS**

**Objectives**
- The course trains the scholars in the art of informed decision making and helps them to appreciate the value of the analytical basis in policy decisions.
- They are given hands on training on the estimation and use of various criteria such as elasticities in making QDPA more meaningful
- The scholars make extensive reviews to get acquainted with the analytical relevance and in drawing inferences.

**Theory**
UNIT-II: 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.
UNIT-IV: 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.
UNIT-V: Social Accounting Matrices and multipliers - Computable General Equilibrium models to assess economy wide impact of policy changes.

**Practical**

**Suggested Readings**
AG ECON 606       ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS

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

Theory
UNIT-I: Importance of agricultural Marketing in economic development, classification/types of markets, components and dimensions of a market - characteristics and role of agricultural prices - data sources for agricultural products and prices.
UNIT-II: Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership - institutional arrangements. Successful case studies.
UNIT-III: Marketing liberalization; Economic Structural Adjustment Programmes, Macro Economic Stabilization, Strategies for Reforming Agricultural Marketing Parastatals, Obstacles to overcome in Commercialization and privatization of agricultural marketing parastatals.
UNIT-IV: Marketing Strategies, Planning and Control: Corporate Planning, business policy and marketing planning; Process of Strategic marketing planning, Content of a marketing plan; Different types of marketing controls; monitoring & evaluating the marketing plan and optimization of resources; principal techniques used in identifying weaknesses in the performance of the marketing plan.
UNIT-V: Time series analysis for prices and arrivals for agricultural commodities - forecast evaluation; methods of forecasting, price indices, Estimation of price elasticities, pricing decisions and strategies, break even analysis.

Practical
Estimation of demand/supply forecasting, supply chain / value chain analysis for different commodities, time series analysis - market integration studies- price discovery price volatility estimation - commodity price forecasting. Determination of administered prices through alternative methods.

Suggested Readings
Crawford IM. 1997. Agricultural and Food Marketing Management, FAO.

AG ECON 607       FARM ORGANISATION AND MANAGEMENT

Objective
To acquaint and impart the training to the students regarding the organization, management and planning of farm and applications of farm management principles and techniques.

Theory
UNIT-I: Management and planning of farm as a unit : Farm Management Vs Management of farm, farm decisions, farm management problems in India, farm resource management, types and systems of farming, factors determining the types of farming.
UNIT-II: Application of farm management, Farm finance and Production economic principles: Laws of production or Diminishing Returns, Cost principle, principle of factor substitution, principle of product substitution, principle of equimarginal returns, principle of time comparison, principle of marginalism, principle of comparative advantage, opportunity cost principle, 3-Râ’s of credit, principle of ownerâ’s equity & increasing risk, Five Cs and Seven Ps.

UNIT-III: Farm organization and planning under risk and uncertainty conditions: Risk & uncertainty: A contrast, sources of risk, measures to manage farm risk, management & planning of farm to mitigate the farm risk, decision and game theories & their application in Agriculture.

UNIT-IV: Tools of Farm Management Analysis: Farm Planning, Production Function analysis, Farm records & accounts, depreciation, farm efficiency measures, budgeting and linear programming.

UNIT-V: Identification and Management of natural resources: Identification & management of natural resources. Factors responsible for deteriorating natural resources, measures to improve efficient use of natural resources & other farm inputs. Practical

Application of Farm Management Principles and Production. Function; Determination of optimum farm programme under varying sets of constraints including weather and price risks.

Suggested Readings

Raju VT & Rao DVS. Economics of Farm Production and Management. Oxford & IBH.
Robertson C.A. An Introduction to Agricultural Economics and Farm Management. Tata McGraw-Hill.
Sankhayan PL. Introduction to Farm Management. Tata McGraw-Hill.

AG ECON 608 AGRICULTURAL FINANCE AND 2+0 SEM - 1 CO-OPERATION

Objective

The objective of this course is to impart knowledge on issues related to agricultural credit requirements, principles of agricultural finance and financial management and recent innovations in agricultural credit. The course would also expose students to the principles and practices of co-operation, revitalization of cooperative management and role of cooperatives new economic policy.

Theory

UNIT-I: Role of credit in agricultural and rural development. Estimates of agricultural credit requirements - investment, production, marketing and consumption. Role of public and private sector banks, and co-operatives in development financing. Classification of agricultural credit. Rural credit structure.

UNIT-II: Principles of agricultural finance and financial management. Agricultural Finance as a part of public finance. Agricultural taxation and subsidies, capital in agriculture and sources of capital. Credit and savings - legal aspects of credit. Credit adjustments. Farm planning as a basis for extension of agricultural credit.

UNIT-III: Recent innovations in extension of credit to agriculture. Rural credit supply and credit gap. Multi agency approach and coordination of credit structure at different levels. Agricultural Credit policy. Principles and practices of cooperation. Successes and failures of co-operative sector in India.


Objective

This is an applied economics course that focuses on the economic analysis of natural resources, and seeks to identify and solve natural resource management problems via mathematical approach using dynamic optimization techniques. During the course, we will encounter bio-economic models of natural resources including the classic and more recent forestry and fisheries models, models of land and water use and extraction of non-renewable resources (such as from a mineral deposit). We will focus on intuition and understanding of the economic analysis rather than complicated mathematical models in this class. That said, natural resource problems are inherently dynamic, so some mathematical modeling of biophysical and economic processes will be required. Using computers as an aid to understanding the models will be an important part of the class. The primary tool will be Microsoft Excel, which is the easiest introduction to computational optimization and graphical representation of the results.

Theory

UNIT-I: Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-renewable resources. Fundamental equation of renewable resources.

UNIT-II: Growth curves of fishery and forest resources. The role of time preference in natural resource use. Simple two-period model of optimal use of renewable and non-renewable resources. Advanced models of optimal resource use - Static Vs. dynamic efficiency in natural resource use. Applications of dynamic programming and optimal control.


UNIT-IV: 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.

UNIT-V: Resource scarcity Ñ Natural resource degradation Ñ Poverty and resource degradation Ñ Natural resource accounting - Pricing and valuation of natural resources Ñ Natural resources policy.

Practical

Objective

The main objective of this course is to provide an advanced treatment of the economic theory of environmental management and policy, externalities and market and non-market approaches to environmental improvement. Topics in economic growth and environmental problems, poverty and environmental degradation, conservation and sustainable economic growth, intergenerational and global environmental problems, policy issues in environmental regulation and management will be covered at a sufficient depth so as to equip the students with the recent developments in the field.

Theory

UNIT-I: Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities - Economics of pollution ï Private vs. Social cost of environmental pollution ï Property rights, environment and development ï Theory of environmental policy.

UNIT-II: Environmental cost benefit analysis - Environmental impact assessment techniques - Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare.


UNIT-IV: Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Coastal externalities - Urbanization and environment - Basic approaches to environmental policy (Tax, subsidy, pollution permits etc.) Green taxes - Political economy of environmental regulation and management.

UNIT-V: Transboundary environmental problems - Economics of global warming, climate change and emission trading - Environment, international trade and development.

Practical

Contemporary global environmental global environmental issues, movement, policies, programmes, laws and other regulatory mechanisms - Criteria for evaluating the environment related projects and review of Environmental Impact Assessment (EIA) techniques - Recreation demand models of environmental valuation - Contingent valuation techniques - Environmental Resource Accounting Techniques - Discussion on the techniques dealing with air pollution and review of case studies on air pollution and its impacts - forest environment and wild life conservation - Green GDP and Green house insurance - Practical considerations and comparison of instruments of environmental policy - Non-point source pollution control methodologies - Environment in macroeconomic modeling - Meta-analysis, economic valuation and environmental economics - Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment - Input output analysis, technology and the environment - Computable general equilibrium models for environmental economics and policy analysis.
**Suggested Readings**


AGRICULTURAL ECONOMICS

List of Journals

- Agricultural Economics Research Review
- Agricultural Finance Review
- Agricultural Marketing
- Agricultural Situation in India
- Agriculture and Agro-industries Journal
- Agriculture Statistics at a Glance
- APEDA Trade yearbook
- Asian Economic and Social Review (Old Series)
- Bulletin of Agricultural Prices
- Economic and Political Weekly
- Economic Survey of Asia and Far East
- FAO Commodity Review and Outlook
- FAO Production Year book
- FAO Trade year book
- Indian Cooperative Review
- Indian Economic Journal
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Economics
- International Food Policy Research Institute Research Report
- Journal of Agricultural Development and Policy
- Journal of Agricultural Economics
- Journal of Agricultural Economics and Development
- Journal of Farm Economics
- Land Economics
- Productivity
- Reserve Bank of India Bulletin
- Rural Economics and Management
- World Agricultural Economics and Rural Sociology Abstracts
- World Agricultural Production and Trade: Statistical Report
- Yojana

e- Resources

- www.pearsoned.com (Pearson Education Publication)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage Publications)
- www.isaieindia.org (Indian Society of Agricultural Economics)
- www.macmillanindia.com (Macmillan Publishing)
- www.icar.org.in (Indian Council of Agricultural Research)
- www.khoj.com (Directory for Agricultural Economics)
- www.ncap.res.in (National Centre for Agricultural Economics and Policy Research)
- www.ncdex.com (National Commodity & Derivatives Exchange Limited)
- www.phdcci.in (PHD Chamber of Commerce and Industry)
- www.ficci.com (Federation of Indian Chambers of Commerce and Industry)
- www.assocham.org (Associated Chambers of Commerce and Industry of India)
- www.apeda.com (Agricultural and Processed Food Products Export Development Authority)
- www.mpeda.com (Marine Products Export Development Authority)
Suggested Broad Topics for Master’s and Doctoral Research

- Economics of irrigation water in different agro-climatic conditions
- Potential of exports of agri-products
- Potential domestic as well as international markets for value added agri-products
- Demand and supply gap of different agri-products and agri-inputs
- Economic analysis of new agri-technologies
- Input use efficiency in different agro-climatic conditions
- Income and expenditure pattern in rural areas
- Saving and investment pattern in rural areas
- Return from investment in agriculture research
- Marketing of agri-products in WTO regime
- Impact of WTO on agricultural economy
- Impact of agricultural credit on socio-economic condition of the farmers
- Optimization of production process to reduce the cost of production
- Economic analysis of diversification, processing and value addition in agriculture sector
- Emerging international marketing scenario of agri-products
- Extent of farmers’ indebtedness in different agro-climatic conditions
### AGRICULTURAL METEOROLOGY

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* Compulsory for Master's programme

To be taught by: 1 Agricultural Meteorology; 2 Agricultural Meteorology and Agronomy; 3 Statistics
AGM 501  FUNDAMENTALS OF METEOROLOGY  2+1  SEM - I
AND CLIMATOLOGY

Objective
To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory
UNIT-I: Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation of pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostrophic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.
UNIT-II: Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, hydrostatic equation, saturation deficit, stability and instability conditions in the atmosphere.
UNIT-III: Lapse rates-ascent of dry and moist air, condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.
UNIT-IV: Effect of earth’s rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon, El Nino, La Nina and ENSO.
UNIT-V: Measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function; synoptic, numerical, graphical, spatial analysis of weather systems and charts technique, thermal and comfort indices.

Practical
• Agromet observatory- different classes of observatories (A, B, C)
• Measurements and calculations of weather parameters.
• Weather chart preparation and identification of pressure systems
• Statistical technique for computation of normals, moving average, Markov chain model etc.

Suggested Readings

AGM 502/ AGRON 505  METEOROLOGY

Objective
To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory
UNIT-I: Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.
UNIT-II: Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.
UNIT-III: Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; introduction to GIS, GPS and remote sensing; use of satellite imageries and synoptic charts in weather forecasting; meteorological aspects of forest fires and their control
UNIT-IV: Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.
UNIT-V: Concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.
UNIT-VI: Climatic change, green house effect, CO2 increase, global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India and Haryana.

Practical
- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relationship in different crops.
- Working with dynamic and simulation models.
- Preparation of weather based agro-advisories.

Suggested Readings

AGM 503  MICROMETEOREOLOGY  2+1  SEM - II

Objective
To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere.

Theory
UNIT-I: Properties of atmosphere near the earth's surface; exchange of mass, momentum and energy between surface and overlying atmosphere, exchange coefficients, similarity hypothesis, shearing stress, forced and free convection.
UNIT-II: Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing length; temperature instability; microclimate near the bare ground, unstable and inversion layers, soil moisture and temperature variation with depth; Richardson number, Reynold's analogy.
UNIT-III: Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; concepts of evapotranspiration and its estimation approaches.
UNIT-IV: Influence of topography on microclimate; shelter belts and wind breaks, microclimate in crop fields, forests, glass and plastic houses.

Practical
- Micrometerological measurements in crop canopies
- Determination of ET by different methods

Suggested Readings
AGM 504  AGRO-Meteorological Instrumentation and Measurements  1+2  SEM - II

Objective
To impart the theoretical and practical knowledge of instruments/equipments used for measurement of agro-meteorological variables.

Theory
UNIT-I: Fundamentals of measurement techniques; exposure and operation of meteorological instruments/equipments in agromet observatories; theory and working principles of barometers, thermometers, psychrometers, hygrometer and thermo-hygrograph.
UNIT-II: Radiation and temperature instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, quantum radiation sensors, thermographs, and infra-red thermometer.
UNIT-III: Precipitation, dew and wind instruments: working principles of rain gauge, self recording rain gauge, Duvedani dew gauges, anemometer, wind vane and anemograph.
UNIT-IV: Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter and pressure bomb apparatus.
UNIT-V: Soil thermometers, soil heat flux plates and instruments for measuring soil moisture.
UNIT-VI: Automatic weather station I data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical
- Working with the above instruments
- Computation and interpretation of the data

Suggested Readings

AGM 505  Soil Water Balance Climatology  2+1  SEM - II

Objective
To impart the theoretical and practical knowledge of soil water balance and its components

Theory
UNIT-I: Basic Laws of radiation; radiation interaction with plant environment; energy balance in atmosphere and crop canopy.
UNIT-II: Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.
UNIT-III: Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration; modified techniques.
UNIT-IV: Influence of microclimate, plant, soil and cultural factors on ET; techniques of lysimetry in measuring actual evapotranspiration.
UNIT-V: Crop coefficients; irrigation scheduling based on evapotranspiration; water use efficiency and its management, dry matter, yield-ET functions; estimation of evapotranspiration through satellite imageries I MODIS, TERRA, AQUA, AVHRR, NOVA etc.

Practical
- Measurement and evaluation of radiation components
- Measurement of wind and temperature profiles near the ground
Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods.

Suggested Readings

AGM 506/AGRON 603
CROP PRODUCTION AND SYSTEM 1+2 SEM - II
MODELING
(To be taught jointly by Agricultural Meteorology and Agronomy)

Objective
To impart the theoretical and practical knowledge of various models for estimation of crop responses.

Theory
UNIT-I: Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.
UNIT-II: Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relations.
UNIT-III: Potential production: leaf and canopy CO₂ assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.
UNIT-IV: Empirical and statistical crop weather models, their application with examples; regression models - incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e.g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; verification, calibration and validation of models; models for forecasting of pests and diseases.

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 elements and crop management practices
- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP etc.

Suggested Readings
Objective
To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory
UNIT-I: Historical reviews and theories of weather modification, present status of weather modification for agriculture; horticulture; atmospheric composition and green house effect.
UNIT-II: Scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.
UNIT-III: Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture and horticulture in the region concerned; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.
UNIT-IV: Approaches, tools and strategies to deal with risks; Methods for weather and climate related risk assessments; mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.
UNIT-V: Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; challenges for developing coping strategies including transferring risks through insurance schemes; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings

Objective
To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory
UNIT-I: Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.
UNIT-II: Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth’s surface; remote sensors in visible, infrared and microwave regions.
UNIT-III: Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.
UNIT-IV: Data acquisition system, data processing, storage and dissemination; digital image processing and information extraction.
UNIT-V: Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.
UNIT-VI: Digital techniques for crop discrimination and identification; crop stress detection - soil moisture assessment, inventory of ground water and satellite monitoring of crop disease and pest infestation.
UNIT-VII: Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- Software and hardware requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations
- Differentiation of different degraded soils
- Time domain reflectometry
- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies

Suggested Readings

Curan PJ. Principles of Remote Sensing. ELBS/Longman.

AGM 509 APPLIED AGRICULTURAL CLIMATOLOGY 1+2 SEM - I

Objective
To impart the theoretical and practical knowledge of computation of different bio-climatic parameters and their applications in the agriculture.

Theory

UNIT-I: Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.
UNIT-II: Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.
UNIT-III: Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.
UNIT-IV: Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.
UNIT-V: Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agroclimatic indices using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

### Suggested Readings

Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.


### AGM 601 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

#### Objective

To impart the theoretical and practical knowledge of climate change and their sources.

#### Theory

**UNIT-I**: Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; astronomical predictions: lunar cycle, sunspot cycle, solar-lunar tides, Chandlers compensation, blocking highs.

**UNIT-II**: Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services; climate change and crop diversification, loss of biodiversity, microbes and pest dynamics; climate change and storage, climate change and weed management.

**UNIT-III**: Sensitivity, adaptation and vulnerability: system’s sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

**UNIT-IV**: Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

**UNIT-V**: Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods etc.

#### Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture
- Advance methodology of assessing the impact of climate change on crops

#### Suggested Readings


### AGM 602 WEATHER FORECASTING

#### Objective
To impart theoretical and practical knowledge of forecasting techniques used for weather prediction and preparation of agro-advisories.

#### Theory

**UNIT-I**: Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.

**UNIT-II**: Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nanotechnological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior; various methods of verification of location-specific weather forecast.

**UNIT-III**: Weather based advisories: interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination.

**UNIT-IV**: Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

**UNIT-V**: Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behavior of clouds.

#### Practical
- Exercise on weather forecasting for various applications
- Preparation of weather-based agro-advisories using various approaches and synoptic charts.

#### Suggested Readings


### AGM 603 AIR POLLUTION METEOROLOGY

#### Objective
To impart the theoretical and practical knowledge of air pollution.

#### Theory

**UNIT-I**: Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution.

**UNIT-II**: Sources of air pollution; classification and properties of air pollutants; emission sources, importance of anthropogenic sources; behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.

**UNIT-III**: Meteorological factors in the dispersion of air pollutants: topographical, geographical and large scale meteorological factors attached air pollution; meteorological conditions and typical plume forms; air pollution forecasting - Gaussian diffusion models, Numerical dispersion models.

**UNIT-IV**: Air quality standards; effect of air pollution on biological organisms; ozone layer depletion; air pollution control technologies; management of air pollution; principles of diffusion of particulate matter in the atmosphere; air pollution laws and standards.
UNIT-V: Air pollution sampling and measurement: types of pollutant sampling and measurement, ambient air sampling, collection of gaseous air pollutants, collection of particulate pollutants, stock sampling: analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.

UNIT-VI: Scales of air pollution: local, urban, regional, continental and global.

Practical
- Measurement of different air pollutants
- Measurement of visibility
- Measurement of ozone and Aerosol Optical Thickness (AOT)
- Study of temperature profile at different heights for determination of stability of the atmosphere
- To determine height of partial flume through chimani
- To study the effect of temperature on vegetables, orchards and agricultural crops

Suggested Readings

AGM 604 WEATHER, CLIMATE AND LIVESTOCK 2+1 SEM - II

Objective
To impart the theoretical and practical knowledge of weather, climate for livestock management.

Theory
UNIT-I: Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.
UNIT-II: Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders.
UNIT-III: Meteorological conditions prevailing in animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors.
UNIT-IV: Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.
UNIT-V: Management of livestock to reduce greenhouse gas emission.

Practical
- Measurement of temperature, humidity and net radiation
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of energy fluxes on body
- Measurements of CO2 and methane in animal farm house

Suggested Readings
AGM 605  ANALYTICAL TOOLS AND METHODS  2+1  SEM - I
FOR AGRO-METEOROLOGY

Objective
To impart the theoretical and practical knowledge of new tools for analysis of agro-climatic features.

Theory
UNIT-I: Review of agro-climatic approaches; characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.
UNIT-II: Network spacing; spatial and temporal methods; GIS fundamentals and applications; numerical characterization of climatic features; crop response to climate, time lags, time and distance constants, hysteresis effects.
UNIT-III: Influence of climate on stress-response relations; thermal time approach in agroclimatology - heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction; comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.
UNIT-IV: Instrumentation and sampling problems; design of agro-meteorological experiments.
UNIT-V: Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual Basic.
UNIT-VI: Empirical and statistical crop weather models and their application with examples; incorporating weather, soil, plants and other environment related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation models; forecasting models for insects and diseases.

Practical
- Calculation of continentality factors
- Climatic indices and climogram
- Agrometeorological indices: Degree-days, photothermal units, heliothermal units, phenothermal index
- Crop growth rates
- Analysis of thermogram, hyrogram, hyetogram, sunshine cards etc. stream lines and wind roses and statistical analysis of climatic data
- Working with statistical models: crop yield forecasting, crop weather relationship and insect & disease forecasting models
- Working with crop simulation models
- Small programme writing in computer languages like BASIC, FORTRAN, C, C++ and Visual Basic
- Geographical Information System

Suggested Readings

AGM 606  STRATEGIC USE OF CLIMATIC  2+1  SEM - II
INFORMATION

Objective
To impart the theoretical and practical knowledge of climatic hazards and their mitigations.

Theory
UNIT-I: Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters (hazards and vulnerabilities) suffered in the concerned continent/region / country/sub-region and their documented or remembered impacts; hazards and their relation to agricultural production risks (intra- and inter-annual); efforts made in protection mitigating impacts of (future) disasters (prevention); trends discernable in occurrence and character of disasters, if any.
UNIT-II: Selection of appropriate land use and cropping patterns: present land use and cropping patterns in the continent/region/country/sub-region concerned as related to environmental issues; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.
UNIT-III: Preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

UNIT-IV: Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural inputs and determination of input efficiencies; other factors determining inputs and input efficiency of the region.

UNIT-V: Selection of livestock management: livestock management patterns in the continent/region/country/sub-region concerned as related to environmental issues; outlook for present livestock management strategies and possible alternatives from an environmental point of view; recent trends in livestock management strategies.

UNIT-VI: Adoption of microclimate modification techniques: microclimate modification techniques practiced in the continent/country/sub-region concerned; possible improvements in adoption of microclimate modification techniques, in view of climate variability and climate change; local trends in adoption of such techniques.

Practical
- Outlook for present land use and cropping patterns and possible alternatives from environmental point of view
- Recent trends in land use and cropping patterns
- Agro-meteorological services to increase farmers design abilities of land use and cropping patterns
- Systematic and standardized data collection on protection measures against extreme climate

Suggested Readings

AGM 607/ STAT 511 SCIENTES
(To be taught by Statistics)

Objective
This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory
UNIT-I: Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability, Random variable and mathematical expectation.
UNIT-II: Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications, concept of sampling distribution: chi-square, t and F distributions., Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.
UNIT-IV: Non-parametric tests- sign, Wilcoxon, Mann-Whitney U-test, Kruskal-Wallis test, run test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance,

UNIT-V: Introduction to multivariate statistical analysis.

Practical
Exploratory data analysis, Box-Cox plots; Fitting of distributions - Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions-chi-square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis. Non-parametric tests.

Suggested Readings

AGM 608 DATABASE MANAGEMENT AND COMMERCIALIZATION OF AGROMETEOROLOGICAL DATA IN E-SERVICES

Objective
To impart knowledge on management of agromet data and train the students in commercialization of agrometeorological data through e-services.

Theory
UNIT-I: Data and information; types of data; climate, soil and crop data; Importance of database management; data requirements; data collection and recording (Automatic and manual).
UNIT-II: Data structure/format; quality control of data; techniques of climatic data generation; missing data; introduction to different software for database management.
UNIT-III: Remote sensing data - maps, imageries and digital data of crop, soil and weather variables
UNIT-IV: Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research.
UNIT-V: Availability, accessibility and security of data; evaluating the cost of data; e-management of data.

Practical
- Types of instruments and data recording
- AWS data retrieval, storage and transfer
- Exposure to different software for Agromet data analysis; exposure to Statistical software
- Remote sensing data analysis, temporal and spatial analysis of data; exposure to GIS
- Value addition to data; Introduction to internet protocols
- Uploading and downloading data, password and security of data
- e-management of data

Suggested Readings
Panse VG & Sukhatme PV. 1983. *Statistical Methods for Agricultural Workers*, ICAR.
AGRICULTURAL METEOROLOGY

List of Journals

- Agricultural and Forest Meteorology
- Agricultural Systems
- Agricultural Systems and Information Technology Newsletter
- Agronomy Journal
- Atmospheric Research
- Canadian Water Resource Journal
- Climate Dynamics
- Climate Research
- Climatic Change
- Computers and Electronics in Agriculture
- Crop Science
- Ecological Modelling
- Environmental Monitoring and Assessment
- GIS India
- Hydrology Journal
- Indian Journal of Environmental Protection
- International Journal of Climatology
- International Journal of Remote Sensing
- Italian Journal of Agrometeorology
- Journal of Agricultural Meteorology
- Journal of Agrometeorology
- Journal of Applied Meteorology
- Journal of Applied Hydrology
- Journal of Applied Meteorology and Climatology
- Journal of Earth Systems Science
- Journal of Hydrologic Engineering
- Journal of Hydrometeorology
- Journal of Weather Modification Association
- Mausam
- Monthly Climatological Data for the World
- Photonirwachak
- Pollution Research
- Remote Sensing of Environment
- Vatavaran
- Vayu Mandal
- Water Resource Research
- Weather
- Weather and Forecasting
- WMO Bulletin

Suggested Broad Topics for Master’s and Doctoral Research

- Microclimatic studies in crops and control climate
- Crop-weather interaction studies in field, vegetable and horticultural crops
- Crop-weather-pest interaction studies
- GIS approach in agro-ecological zoning and crop environment characterization
- Testing and validation of various existing crop simulation models to determine the production potentials in different regions of the state for major crops
- Climate change and sustainability i regional scenarios
- Weather modification studies
- Development of weather based model for major crops of the state
- The crop acreage and yield estimates for state using remote sensing approach
• Studies involving the ground-based spectral signatures for stress detection and yield modeling of important crops in the state
• Weather-based agro advisories, impact assessment and related issues
• Impact assessment studies in livestock and other agricultural production systems
• Evapo-transpiration studies using different approaches
• Extreme weather events, their impact on agriculture and their alleviation
• Agro-climatic resource characterization with reference to crops
• Crop-weather relationship for major crops
• Crop-growth simulation modeling
• Development of weather-based forewarning models for pest and disease
• Impact of climate change on agriculture
• Application model based agro-advisories to farmers
• Application of remote sensing in large scale crop condition assessment and yield prediction
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Course Structure

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*Compulsory for Master’s programme; **Compulsory for Doctoral programme and additional at least one more course from 600 series

To be taught by: ① Agrometeorology; ② Agronomy; ③ Forestry and Agronomy; ④ Agrometeorology and Agronomy
AGRONOMY

Course Contents

AGRON 501 MODERN CONCEPTS IN CROP PRODUCTION 3+0 SEM - I

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

Theory
UNIT-I: Crop growth analysis in relation to environment; geo-ecological zones of India.
UNIT-II: Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability, Baule unit.
UNIT-III: Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.
UNIT-IV: Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress.
UNIT-V: Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.

Suggested Readings

AGRON 502 PRINCIPAL AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT 2+1 SEM - II

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

Theory
UNIT-I: Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.
UNIT-II: Criteria of essentiality of nutrients; Essential plant nutrients - their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.
UNIT-III: Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.
UNIT-IV: Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.
UNIT-V: Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermin compost and residue wastes in crops.

Practical
Determination of total N, P, K and S in plants
Interpretation of interaction effects and computation of economic and yield optima

**Suggested Readings**

**AGRON 503**

**PRINCIPLES AND PRACTICES OF WEED MANAGEMENT**

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

**Theory**
**UNIT-I**: Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification; weed indices.
**UNIT-II**: Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.
**UNIT-III**: Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation.
**UNIT-IV**: Weed management in major crops and cropping systems; parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control.
**UNIT-V**: Integrated weed management; cost : benefit analysis of weed management.

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

**Suggested Readings**

**AGRON 504**

**PRINCIPLES AND PRACTICES OF WATER MANAGEMENT**

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

**Theory**
**UNIT-I**: Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.
UNIT-II: Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition.
UNIT-III: Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and polyhouses.
UNIT-IV: Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency.
UNIT-V: Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

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

Suggested Readings

AGRON 505/AGM 502
FUNDAMENTALS OF AGRICULTURAL METEOROLOGY 2+1 SEM - I

Objective
To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory
UNIT-I: Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.
UNIT-II: Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.
UNIT-III: Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.
UNIT-IV: Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.
UNIT-V: Meteorological aspects of forest fires and their control; concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.
UNIT-VI: Climatic change, green house effect, CO2 increase, global warming and their impact on agriculture; concept and types of drought; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical
- Preparation of crop weather calendars
Development of simple regression models for weather, pest and disease relation in different crops.
Preparation of weather based agro-advisories
Use of automated weather station (AWS)

Suggested Readings

AGRON 506 AGRONOMY OF MAJOR CEREALS AND PULSES 2+1 SEM - I

Objective
To teach the crop husbandry of cereals and pulse crops.

Theory
Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of
UNIT-I: Rabi cereals.
UNIT-II: Kharif cereals.
UNIT-III: Rabi pulses.
UNIT-IV: Kharif pulses.

Practical
Phenological studies at different growth stages of crop
Estimation of crop yield on the basis of yield attributes
Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
Working out growth indices (CER, CGR, RGR, NAR, LAD), aggressiveness, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems of different crops
Estimation of protein content in pulses
Planning and layout of field experiments
Judging of physiological maturity in different crops
Intercultural operations in different crops
Determination of cost of cultivation of different crops
Working out harvest index of various crops
Study of seed production techniques in various crops
Visit of field experiments on cultural, fertilizer, weed control and water management aspects
Visit to nearby villages for identification of constraints in crop production

Suggested Readings
Prasad, Rajendra. 2002. Text Book of Field Crop Production. ICAR.
AGRON 507 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS

Objective
To teach the crop husbandry of oilseed, fiber and sugar crops.

Theory
Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and processing of the produce for maximum production of:
UNIT-I: Rabi oilseeds ï Rapeseed and mustard, linseed
UNIT-II: Kharif oilseeds - Groundnut, sesame, castor, sunflower, soybean, Safflower
UNIT-III: Fiber crops - Cotton, jute, sunhemp
UNIT-IV: Sugar crops ï Sugar-beet and sugarcane.

Practical
- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (LER, CGR, RGR, NAR, LAD) aggressivity, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings
Prasad, Rajendra. 2002. Text Book of Field Crop Production. ICAR.

AGRON 508/PSMA 503 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS

Objective
To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices and processing.

Theory
UNIT-I: Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.
UNIT-II: Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nux vomica, Rosadle etc).
UNIT-III: Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium).
UNIT-IV: Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

UNIT-V: Post harvest handling – drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

Practical
- Identification of crops based on morphological and seed characteristics
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants

Suggested Readings

AGRON 509 AGRONOMY OF FODDER AND FORAGE CROPS 2+1 SEM - II

Objective
To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory
UNIT-I: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne etc.
UNIT-II: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses lime, napier grass, Panicum, Lasiurus, Cenchrus etc.
UNIT-III: Year-round fodder production and management, preservation and utilization of forage and pasture crops.
UNIT-IV: Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.
UNIT-V: Economics of forage cultivation uses and seed production techniques.

Practical
- Practical raining of farm operations in raising fodder crops;
- Canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation

Suggested Readings
Narayanan TR & Dabadghao PM. 1972. Forage Crops of India. ICAR.
Objective
To teach crop husbandry of different forage, fodder and agroforestry crops/trees along with their processing.

Theory
UNIT-I: Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India; grass cover of India; problems and management of grasslands.
UNIT-II: Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.
UNIT-III: Agroforestry: definition and importance; agroforestry systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.
UNIT-IV: Crop production technology in agro-forestry and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical
- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastoral systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

Suggested Readings
Dabadghao PM & Shankaranarayan KA. 1973. The Grass Cover in India. ICAR.
Shah SA.1988. Forestry for People. ICAR.
AGRON 511  CROPPING SYSTEMS AND SUSTAINABLE 2+0 SEM - I AGRICULTURE

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

Theory
UNIT-I: Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.
UNIT-II: Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.
UNIT-III: Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.
UNIT-IV: Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system.
UNIT-V: Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Suggested Readings

AGRON 512  DRYLAND FARMING AND WATERSHED 2+1 SEM - I MANAGEMENT

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

Theory
UNIT-I: Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.
UNIT-II: Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.
UNIT-III: Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.
UNIT-IV: Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop managements techniques, seeding and efficient fertilizer use.
UNIT-V: Concept of watershed resource management, problems, approach and components.

Practical
Â Seed treatment, seed germination and crop establishment in relation to soil moisture contents
Â Moisture stress effects and recovery behaviour of important crops
Â Estimation of moisture index and aridity index
Â Spray of anti-transpirants and their effect on crops
Â Collection and interpretation of data for water balance equations
Water use efficiency
• Preparation of crop plans for different drought conditions
• Study of field experiments relevant to dryland farming
• Visit to dryland research stations and watershed projects

Suggested Readings
Dhruv Narayan VV. 2002. Soil and Water Conservation Research in India. ICAR.
Katyal JC & Farrington J. 1995. Research for Rainfed Farming. CRIDA.
Venkateshwara J. 2004. Rainfed Agriculture in India. Research and Development Scenario. ICAR.

AGRON 513 PRINCIPLES AND PRACTICES OF 2+1 SEM - II ORGANIC FARMING

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

Theory
UNIT-I: Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use, minimum tillage; shelter zones, hedges, pasture management, agro-forestry.
UNIT-II: Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers.
UNIT-III: Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.
UNIT-IV: Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides.
UNIT-V: Socio-economic impacts; marketing and export potential; inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical
• Aerobic and anaerobic methods of making compost
• Making of vermicompost
• Identification and nursery raising of important agro-forestry tress and tress for shelter belts
• Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field
• Visit to an organic farm
• Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Suggested Readings


**AGRON 601 CURRENT TRENDS IN AGRONOMY 3+0 SEM - II**

**Objective**

To acquaint the students about recent advances in agricultural production.

**Theory**

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

UNIT-II: Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures.

UNIT-III: Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agroforestry, allelopathy.

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

UNIT-V: Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

**Suggested Readings**


**AGRON 602 CROP ECOLOGY 2+0 SEM - II**

**Objective**

To acquaint the students about the agricultural systems, agro-ecological regions, and adaptation of crops to different agro-climatic conditions.

**Theory**

UNIT-I: Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply.

UNIT-II: Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.

UNIT-III: Physiological response of crop plants to light, temperature, CO2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.

UNIT-IV: Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production.
UNIT-V: 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.

Suggested Readings


AGRON 603/ CROP PRODUCTION AND SYSTEM 1+2 SEM - II
AGM 506 MODELING (To be taught jointly by Agricultural Meteorology and Agronomy)

Objective
To impart the theoretical and practical knowledge of various models for estimation of crop responses.

Theory
UNIT-I: Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.
UNIT-II: Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams.
UNIT-III: Potential production: leaf and canopy CO2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.
UNIT-IV: Empirical and statistical crop weather models their application with examples; regression models - incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e.g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; forecasting of pests and diseases; verification, calibration and validation of models.

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
- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP

Suggested Readings

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

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

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

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

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

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

Suggested Readings

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

UNIT-I: Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

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

UNIT-III: Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

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

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

UNIT-VI: Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer participation in command areas; irrigation legislation.

Suggested Readings


AGRON 606 ADVANCES IN WEED MANAGEMENT 2+0 SEM - I

Objective

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

Theory

UNIT-I: Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects.

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

UNIT-III: Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.

UNIT-IV: Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.

UNIT-V: Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

UNIT-VI: Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical herbicide bioassays.

Suggested Readings

AGRON 607 INTEGRATED FARMING SYSTEMS 2+0  SEM - II
SUSTAINABLE AGRICULTURE

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

Theory
UNIT-I: Farming systems: definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.
UNIT-II: Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.
UNIT-III: Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.
UNIT-IV: Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.
UNIT-V: New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Suggested Readings
Singh SP. (Ed) 1994. Technology for Production of Natural Enemies. PDBC, Bangalore.

AGRON 608 SOIL CONSERVATION AND WATERSHED MANAGEMENT 2+1  SEM - I

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

Theory
UNIT-I: Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.
UNIT-II: Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.
UNIT-III: Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.
UNIT-IV: Land use capability classification, alternate land use systems; agro-forestry; ley farming; jhum management - basic concepts, socio-ethnic aspects, its layout.
UNIT-V: Drainage considerations and agronomic management; rehabilitation of abandoned jhum lands and measures to prevent soil erosion.

Practical
Study of different types of erosion
Field studies of different soil conservation measures
Run-off and soil loss measurements
Laying out run-off plot and deciding treatments
Identification of different grasses and trees for soil conservation
Visit to a soil conservation research centre, demonstration and training centre

Suggested Readings
Dhruvanarayana VV. 1993. Soil and Water Conservation Research in India. ICAR.

AGRON 609
STRESS CROP PRODUCTION

2+1
SEM - I

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

Theory

UNIT-I: Stress and strain terminology; nature and stress injury and resistance; causes of stress.
UNIT-II: Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.
UNIT-V: Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.
UNIT-VI: Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.
UNIT-VII: Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.
UNIT-VIII: Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

Â Determination of electrical conductivity of plant cell sap
Â Determination of osmotic potential and tissue water potential
Â Measurement of transpiration rate
Â Measurement of stomatal frequency
Â Growing of plants in sand culture under salt stress for biochemical and physiological studies
Â Studies on effect of osmotic and ionic stress on seed germination and seedling growth
Â Measurement of low temperature injury under field conditions

Suggested Readings


AGRONOMY

List of Journals

- Advances in Agronomy
- Agricultural Systems
- Agricultural Water Management
- Agriculture, Ecosystems and Environment
- Agronomy Journal
- Annual Review of Plant Physiology
- Applied Ecology and Environment Research
- Australian Journal of Agricultural Research
- Australian Journal of Experimental Agriculture
- Crop Protection
- Environment and Ecology
- European Journal of Agronomy
- Fertilizer Research
- Field Crops Research
- Indian Journal of Agricultural Sciences
- Indian Journal of Agronomy
- Indian Journal of Ecology
- Indian Journal of Weed Science
- Irrigation Science
- Japanese Journal of Crop Science
- Journal of Agricultural Science Cambridge
- Journal of Agronomy
- Journal of Applied Ecology
- Journal of Experimental Botany
- Journal of Farming Systems Research
- Journal of Range Management
- Journal of Sustainable Agriculture
- Netherlands Journal of Agricultural Sciences
- Nutrient Cycling in Agroecosystems
- Pesticide Biochemistry and Physiology
- Plant and Soil
- Plant Production Science
- Soil and Tillage Research
- Swedish Journal of Agricultural Research
- Tropical Agriculture
- Weed Research
Suggested Broad Topics for Master’s and Doctoral Research

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

**MBA (Agribusiness) and MBA(General)**

## Course Structure

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<thead>
<tr>
<th>COURSE NO.</th>
<th>COURSE TITLE</th>
<th>CREDITS</th>
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<tr>
<td>ABM/MGT 501</td>
<td>PRINCIPLES OF MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR</td>
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<td>ABM/MGT 502</td>
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<td>MANAGERIAL ECONOMICS</td>
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<td>ABM/MGT 505</td>
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<td>ABM/MGT 506</td>
<td>HUMAN RESOURCE MANAGEMENT</td>
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<td>ABM/MGT 507</td>
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<tr>
<td>ABM/MGT 509</td>
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<td>ABM/MGT 511</td>
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<td>ABM/MGT 513</td>
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<tr>
<td>ABM/MGT 595</td>
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## ELECTIVES

**MBA (AGRI-BUSINESS MANAGEMENT)**

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<td>FERTILIZER TECHNOLOGY AND MANAGEMENT</td>
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<td>FARM POWER &amp; MACHINERY MANAGEMENT</td>
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**MBA (GENERAL)**

### FINANCE

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<tbody>
<tr>
<td>MGT 516</td>
<td>WORKING CAPITAL MANAGEMENT</td>
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<td>MGT 517</td>
<td>DIRECT TAX LAWS</td>
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<td>MGT 518</td>
<td>FINANCIAL INSTITUTIONS</td>
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<td>MGT 519</td>
<td>STOCK MARKET OPERATIONS</td>
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<tr>
<td>MGT 520</td>
<td>MERCHANT BANKING AND FINANCIAL SERVICES MANAGEMENT</td>
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<tr>
<td>MGT 521</td>
<td>SECURITY ANALYSIS &amp; PORTFOLIO MANAGEMENT</td>
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<td>MGT 522</td>
<td>INTERNATIONAL FINANCIAL MANAGEMENT</td>
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<td>MGT 523</td>
<td>MANAGEMENT CONTROL SYSTEM</td>
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### MARKETING MANAGEMENT

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<td>MGT 526</td>
<td>CONSUMER BEHAVIOUR</td>
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### HUMAN RESOURCE MANAGEMENT

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<td>UNION MANAGEMENT RELATIONS</td>
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<td>INDUSTRIAL PSYCHOLOGY</td>
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<td>MGT 535</td>
<td>COMPENSATION MANAGEMENT</td>
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<td>MGT 536</td>
<td>ORGANISATIONAL CHANGE AND STRESS MANAGEMENT</td>
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<td>MGT 537</td>
<td>LABOUR ECONOMICS</td>
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<td>MGT 538</td>
<td>INDUSTRIAL AND LABOUR LEGISLATION</td>
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<tr>
<td>MGT 539</td>
<td>STRATEGIC HUMAN RESOURCE MANAGEMENT</td>
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**Note:** The course code **ABM** will be for MBA (Agri-Business) and **MGT** will be for MBA (General) programmes, respectively. Each course will be of 100 marks (75 external and 25 internal) except ABM/MGT 595.

* All Students will go for 6-8 week practical summer training in companies after completion of the first year second semester. Students have to present and submit the training report to the Department in the beginning of first semester of second year which will be evaluated internally.
**In Agribusiness programme all five elective courses will be from Agribusiness area. In MBA programme three courses from major and two courses from minor area of specialization will be offered. The areas of specialization for MBA programme will be Marketing, Finance and HRM. However a course will be offered if 25% students of the intake capacity are willing to take up that course.

***Every student will take up a research project in consultation with the advisor/head of the department and will submit a written report to the department before the commencement of second semester examination of second year. External examiner will evaluate and also conduct viva voce based on project report and award marks out of 100.

****In Agribusiness programme all three elective courses will be from Agribusiness area. In MBA programme two courses from major and one course from minor area of specialization will be offered. The areas of specialization for MBA programme will be Marketing, Finance and HRM. However a course will be offered if 25% students of the intake capacity are willing to take up that course.

To be taught by: ¹ Food Science and Technology; ² Soil Science; ³ Entomology, Plant Pathology and Agronomy; ⁴ Seed Science and Technology; ⁵ Livestock Products Technology; ⁶ Fruit Science; ⁷ Farm Machinery and Power Engineering; ⁸ Animal Nutrition; ⁹ Livestock Production Management; ¹⁰ Floriculture and Landscape Architecture; ¹¹ Business Management

**Credit Requirement for MBA**

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<td>Non Credit Compulsory Courses (NC)</td>
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</table>
MBA (Agribusiness) and MBA(General)
Course Contents

ABM/MGT 501  PRINCIPLES OF MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR  3+0

Objective
To acquaint the learner with meaning and concepts of management and organizational behaviour. Focus will be on understanding the concepts, processes, significance, and role of management and organizational behaviour.

Contents
UNIT-IV: Motivation- Types of motivation. Theories of motivation, Applications of motivation. Transactional analysis-Johari window-self fulfilling prophecy, Interpersonal relations-understanding, determinants, and developing; leadership styles and influence process; leadership theories; types of leaders, and effective leader; group dynamics-, types of groups, group formation, Group decision making, Team Building.
UNIT-V: Organizational culture or climate-concept, dimensions, ethos, determinants; organizational conflicts-concepts, sources, implications, and management; organizational changes - types, resistances to change, role of change agents.

Suggested Readings

ABM/MGT 502  BUSINESS ENVIRONMENT  2+0

Objective
To expose learner to the environment in which the business is conducted. Focus will be on understanding micro and macro environmental forces and their impact on business.

Contents
UNIT-II: Industrial policy, liberalisation, privatisation, globalisation, foreign investment, MNCs.
UNIT-III: International business environment, WTO.
UNIT-V: Government Role in Indian Business, role of various business associations in India.

Suggested Readings
Objective
To familiarize the students with the fundamental economic concepts and principles in the context of managerial decision making.

Contents
UNIT-I: Scope of managerial economics, objective of the firm and managerial economics as a tool of decision making; mathematical concepts used in managerial economics.
UNIT-II: Demand analysis - meaning, types and determinants of demand; demand function; demand elasticity; demand forecasting-need and techniques.
UNIT-III: Production, cost and supply analysis- production function, least-cost input combination and returns to scale, cost concepts, cost-output relationship, short and long-run supply functions.
UNIT-IV: Pricing-determinants of price - pricing under different market structures - perfect competition, monopoly, monopolistic and oligopoly; pricing methods in practice
UNIT-V: The national income; circular flow of income: consumption, investment and saving; economic growth- meaning and determinants; phases of business cycles; business decisions under uncertainty;

Suggested Readings

Objective
The objective of this course is to expose the learner to the concept and methods of financial and management accounting. Focus will be on understanding techniques, uses and applications of financial and management accounting.

Contents

Suggested Readings
ABM/MGT 505  BUSINESS LAWS AND ETHICS  2+0

Objective
The objective of this course is to expose the learner to various ethical issues and laws affecting business. Focus will be on understanding provisions of various business laws and also ethical practices to conduct the business properly.

Contents
UNIT-II: Companies Act-1956: incorporation, commencement of business, types of companies, management, winding of companies, Negotiable Instruments Act.
UNIT-V: Nature and importance of ethics and moral standards; corporations and social responsibilities, scope and purpose of business ethics; Ethics in business functional areas; industrial espionage; solving ethical problems; governance mechanism.

Suggested Readings

ABM/MGT 506  HUMAN RESOURCE MANAGEMENT  2+0

Objective
The objective of this course is to expose the learner to the field of human resource management. The focus will be on human resource practices and their utility for managers.

Contents
UNIT-III: Performance Appraisal i Significance and methods, Compensation management, Wage and Salary Administration - Course Objective; Wage Fixation; Fringe Benefits, Incentive Payment, bonus, and Profit Sharing.
UNIT-IV: Industrial Relations-Role and Status of Trade Unions; Collective Bargaining; Worker’s Participation in Management, Career planning and employee retention.
UNIT-V: Quality of work life, employee welfare measure, Disputes and grievance Handling Procedures; Arbitration and Adjudication; Health and Safety of Human Resources; Human Resources accounting, Human Resources outsourcing.

Suggested Readings

ABM/MGT 507  BUSINESS MATHEMATICS AND STATISTICS  2+0

Objective
The objective of this course is to acquaint the learner with the basic concepts of mathematics and statistics used for business decisions. Focus will be on understanding the application of these techniques in solving business problems.
Contents

UNIT-I: Simple Differentiation and Integration, Maxima and Minima; Use of Determinants and Matrices in business decisions and solving linear equations.
UNIT-II: Different approaches to probability, addition and multiplication rules, marginal probability, conditional probability, Bayes Theorem, probability distributions; mathematical expectations; point estimation and interval estimation for population mean and proportions.
UNIT-IV: Simple, partial, and multiple correlations, rank correlation, simple and multiple regression, introduction to Forecasting Methods (Qualitative and Quantitative).
UNIT-V: Hypothesis testing, Null Hypothesis, Level of Significance, One Tail and Two Tail Tests, Type I and Type II Errors, t-Test, F-Test, Z-test, Chi-Square Test, Run Test, Sign Test.

Suggested Readings


ABM/MGT 508 INTRODUCTION TO AGRIBUSINESS MANAGEMENT 2+0

Objective

To acquaint the students regarding the basic concept of agribusiness, agribusiness organizations, value addition, agri-input markets, etc.

Contents

UNIT-I: Role of agriculture in Indian economy; Agri-Business Definition, Nature, Scope and Prospects; Types of Agribusiness;
UNIT-II: Emerging trends in production and changing dimensions of Agri-business in India, Unique features of agri-products in comparison to non-agri-products; Buffer Stock; Procurement and working of Public Distribution System
UNIT-III: Agri-Business Organizations Working and Functioning of Selected Organizations such as Food Corporation of India, Cotton Corporation of India, NAFED, National Bank for Agriculture and Rural Development, Warehousing Corporations etc.
UNIT-IV: Agri-inputs- Seeds, Fertilizers, Agricultural Machinery, Pesticides etc. delivery system and channels in marketing.
UNIT-V: Emerging trends in processing of agricultural output: Degrees of Processing, and Advantages of Processing; Location Factors for Agro Industry, Problems in Processing and suggestions for Improving Efficiency.

Suggested Readings

Acharya SS & Agarwal NL. Agricultural Marketing in India. 4th Ed. Oxford & IBH.

ABM/MGT 509 MARKETING MANAGEMENT 3+0

Objective

The objective of this course is to develop an understanding of the field of marketing. The focus will be on imparting knowledge of the basic concepts, tools, and functions of marketing.

Contents

UNIT-I: The Concept of Marketing Management; Marketing Environment; Marketing Mix, Strategic Marketing, Market Segmentation, Targeting, and Positioning; Buyer Behavior, Marketing Information System, Marketing Organization and Control
UNIT-II: Marketing potential and forecasting, Classification of Products; Product Life Cycle; New Product Development; Product Line and Product Mix; Branding, Packaging and labeling.
UNIT-IV: Types of Distribution Channels; Functions of Channel Members; Channel Management Decisions. 
UNIT-V: Promotion Mix; Introduction to Advertising, Personal Selling, Sales Promotion, Publicity and Public Relations, and Direct marketing; managing integrated marketing promotion, Customer Relationship Management.

Suggested Readings

ABM/MGT 510  FINANCIAL MANAGEMENT   2+0
Objective
The course aims to make students proficient in concepts and techniques of financial management. Focus will be on developing understanding of the application of Financial and investment decisions.

Contents
UNIT-II: Capital Structure, Determinants of size and composition of Capital Structure, Capital Structure Theories; Long term financing and Cost of Capital. 
UNIT-IV: Financial planning and Forecasting, Financial planning for mergers & acquisition, Capital Budgeting, Undiscounted and Discounted cash flow methods of Investment Appraisal; Hybrid finance and lease finance. 
UNIT-V: Business Financing System in India, Money and Capital Markets, Regional and All - India Financial Institutions; venture capital financing and its stages, micro finance and International financial management.

Suggested Readings

ABM/MGT 511  PRODUCTION AND OPERATIONS MANAGEMENT   2+0
Objective
The objective of this course is to expose the learner to the field of production and operations management. The focus will be on imparting knowledge of the basic concepts, tools, and functions of production management.

Contents
UNIT-I: Nature and Scope of Production and Operations Management; Its relationship with Other Systems in the Organization; Factors Affecting System and Concept of Production and Operation Management; Facility location, Types of Manufacturing Systems and Layouts, Layout Planning and Analysis. 

Suggested Readings

ABM/MGT 512 RESEARCH METHODOLOGY 3+0

Objective
The objective of this course is to develop an understanding of research methodology. The focus will be on process and techniques of research.

Contents
UNIT-I: Role and uses of quantitative techniques in analysis and decision making; Meaning, types, and process of research; research methodology in management-exploratory, descriptive, experimental, diagnostic, Problem formulation, formulation of hypotheses.
UNIT-II: Scales of measurement - nominal, ordinal, interval, ratio, Likert scale and other scales; Primary and secondary data, sources of data, instruments of data collection, data editing, classification, coding, validation, tabulation, presentation, analysis.
UNIT-III: Concept of Sampling, Probability and non-probability sampling techniques including Simple Random Sampling, Stratified Sampling, Multi-stage Sampling, Systematic Sampling, Purposive Sampling, Quota sampling, judgment sampling, and convenience sampling, sample size determination, sampling and non-sampling errors.
UNIT-IV: ANOVA- one way and two way classification, Randomized Block Design and Latin Square Design; Index Numbers.
UNIT-V: Discriminant and dummy variable analysis; Factor analysis, cluster analysis, conjoint analysis, multi-dimensional analysis etc.; Report writing: Types of report, essentials and contents of good report writing.

Suggested Readings

ABM/MGT 513 OPERATIONS RESEARCH METHODS 2+0

Objective
The objective of this course is to acquaint the learner with the applications of some important Operations Research techniques. Focus will be on understanding the use of these techniques in solving business problems.

Contents
UNIT-I: Linear Programming: Objective, Assumptions, Formulation of Linear Programming Problem, Graphic Method, Simplex method, Transportation and Assignment Problems.
UNIT-II: Inventory control Models: Costs Involved in Inventory Management, Types of Inventory, Economic Order Quantity (EOQ) Model, Continuous Review (Q) System, Periodic Review (P) System.
UNIT-IV: Decision making under Risk and uncertainties, Decision problems, Maximax Criterion, Maximin Criterion, Minimax Regret Criterion, Laplace Criterion, Pay off Tables, Decision Trees, Expected Value of perfect Information.
UNIT-V: Game Theory - Two -Person Zero-Sum Game, Simulation, Network analysis ñ PERT & CPM.
Suggested Readings

ABM/MGT 514  PROJECT MANAGEMENT AND ENTREPRENEURSHIP DEVELOPMENT 2+0

Objective
The objective of this course is to expose the learner to the fields of project management and entrepreneurship development. Focus will be to train the students to develop new projects and encouraging them to start their own ventures.

Contents
UNIT-I: Concept, characteristics of projects, types of projects, project identification, and Project's life cycle.
UNIT-II: Project feasibility- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis.
UNIT-III: Project scheduling and resource allocation; Financial appraisal/evaluation techniques- discounted/non-discounted cash flows; Net present values, profitability index, Internal rate of returns; Cost benefits ratio; Accounting rate of return, Pay back period, Project implementation; Cost over run, Project control and information system.
UNIT-IV: Entrepreneurship, Significance of entrepreneurship in economic development, qualities and functions of entrepreneur, entrepreneurship development programs and role of various institutions in developing entrepreneurship.
UNIT-V: Life cycles of new business, environmental factors affecting success of a new business, reasons for the failure and visible problems for business, Developing effective business plans, Procedural steps in setting up of an industry.

Suggested Readings

ABM/MGT 515  MANAGEMENT INFORMATION SYSTEMS 2+0

Objective
The objective of this course is to develop an understanding and utility of MIS. The focus will be on imparting knowledge of the basic concepts, development, functions and usage of MIS.

Contents
UNIT-I: The concept of MIS I Definition, importance, Course Objective, pre-requisites, advantages and challenges; Information Needs of organization, MIS and Decision I Making.
UNIT-IV: Development of MIS for an organization – The concept and stages of System Development Life Cycle.
UNIT-V: Information Technology– concept, applications, advantages and pre-requisites, Choice of Information Technology, Social and Legal Dimension of IT.

Suggested Readings
ELECTIVES
Agribusiness Management

ABM 516  RURAL MARKETING  2+0
Objective
To objective of this course is to develop understanding regarding issues in rural markets like marketing environment, consumer behaviour, distribution channels, marketing strategies, etc.

Contents
UNIT-I: Concept and scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India, rural communication and distribution.
UNIT-II: Environmental factors - socio-cultural, economic, demographic, technological and other environmental factors affecting rural marketing.
UNIT-III: Rural consumers' behaviour - behavior of rural consumers and farmers; buyer characteristics and buying behaviour; Rural v/s urban markets, customer relationship management, rural market research.
UNIT-IV: Rural marketing strategy - Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; product mix, pricing Course Objective, pricing policy and pricing strategy, distribution strategy.
UNIT-V: Promotion and communication strategy - Media planning, planning of distribution channels, and organizing personal selling in rural market in India, innovation in rural marketing.

Suggested Readings

ABM 517  AGRICULTURAL MARKETING MANAGEMENT  2+0
Objective
The objective of this course is to give the students an understanding of concept, various policies, strategies and decisions relating to marketing that can be developed by agribusiness firms.

Contents
UNIT-I: Meaning and scope, agricultural marketing and economic development; Agricultural market structure  meaning, components and dynamics of market structure; marketing strategy  meaning & significance, formulation of marketing strategy; agribusiness marketing environment, design of marketing mix, market segmentation and targeting, determinants of consumer's behaviour.
UNIT-III: Pricing policies and practice for agribusiness - determinants of price, objectives of pricing policies and pricing methods.
UNIT-IV: Promotional management - advertising planning and execution; sales promotion; grading and standardization.
UNIT-V: Distribution management - storage and warehousing, and transportation management for agricultural products; marketing agencies/intermediaries  roles and functions; distribution channels involved in agribusiness.

Suggested Readings
ABM 518  FOOD TECHNOLOGY AND PROCESSING MANAGEMENT  2+0  
(To be taught by Food Science & Technology)  

Objective  
The objective of this course is to acquaint the students with different food processing techniques and their management.  

Contents  
UNIT-I: Present status of food industry in India; Introduction to unit operations of food industry; Deteriorative factors and hazards during processing, storage, handling and distribution. Supply chain management  
UNIT-II: Elements of food processing & preservations by manipulation of various parameters. Application of heat, radiations, chemicals and microbes and enzymes.  
UNIT-III: Handling and processing of fruits and vegetables, milk & milk products, egg, poultry, fish, meat, cereals, pulses, nuts & oilseeds etc. Packaging of foods.  
UNIT-IV: Risk management; Laws and regulations related to food industry, food production and marketing; Quality management systems, National & International quality standards, PFA, ISO, Codex etc.  
UNIT-V: Case studies on project formulation in various types of food industries - milk and dairy products, fruits and vegetables, cereal and pulse milling, bakery and confectionery, oil and fat processing, honey production etc.  

Suggested Readings  
Selected articles from journals.  

ABM 519  FERTILIZER TECHNOLOGY AND MANAGEMENT  2+0  
(To be taught by Soil Science)  

Objective  
The objective of this course is to acquaint the students in latest advances in fertilizer technology management.  

Contents  
UNIT-I: Fertilizer development - concept, scope, need, resource availability; types of fertilizers, grading and chemical constituents, role of fertilizers in agricultural production, production and consumption of fertilizer in India.  
UNIT-II: Raw material needed and principles of manufacturing of nitrogenous, phosphatic and potassic fertilizers, sources of secondary nutrient and micro-nutrient.  
UNIT-III: Quality control and legal aspects- fertilizer control order.  
UNIT-IV: Testing facilities; constraints in fertilizer use and emerging scenario of fertilizer use; fertilizer distribution, fertilizer storage.  
UNIT-V: Field trials and demonstration, scope of bio-fertilizer; environmental pollution due to fertilizer use.  

Suggested Readings  
Fertilizer Control Order (different years). Fertilizer Association of India, New Delhi.  
Fertilizer Statistics (different years). Fertilizer Association of India, New Delhi.  
Indian Journal of Fertilizers (different years). Fertilizer Association of India, New Delhi.  

ABM 520  MANAGEMENT OF AGRO CHEMICAL INDUSTRY  2+0  
(To be taught by Entomology, Plant Pathology and Agronomy)  

Objective  
To familiarize the students with the agrochemicals, their structure, classification and development and also how to manage the agro-chemical industries.
Contents

UNIT-I: Agro-chemicals: Definition and classification; Basic knowledge of agro-chemicals; role and status of agro-chemical industry in India; Herbicides ï Classification and Introduction, knowledge of different pesticides.

UNIT-II: Insecticides ï Definition and classification based on (a) Mode of Entry (b) Mode of Action and (c) Chemical Structure; preliminary knowledge of mode of action of insecticides; knowledge of plant protection equipments.

UNIT-III: Fungicides ï Classification and preliminary knowledge of commonly used fungicides; Biomagnifications of pesticides and pesticidal pollution.

UNIT-IV: Introductory knowledge about development of agro-chemicals; Insecticidal poisoning, symptoms and treatment; Main features of Insecticide Act.

UNIT-V: Directorate of Plant Protection, Quarantine and Storage ï A brief account of its organizational set up and functions; IPM Concept ï Bio-pesticides ï Plant products.

Suggested Readings


ABM 521 FARM BUSINESS MANAGEMENT 2+0

Objective

To acquaint the students with the basic principles of farm management dealing with the analysis of farm resources having alternatives within the framework of resource restrictions.

Contents

UNIT-I: Nature, scope, characteristics and role of farm business management; farm management decisions; farm management problems.

UNIT-II: Principles of farm management decisions ï principle of variable proportion, cost principle, principle of factor substitution, law of equi-marginal returns, opportunity cost principle, etc.

UNIT-III: Tools of farm management and farm business analysis ï farm planning and budgeting; Farm records and accounts, types and problems in farm records and accounts, net worth statement, farm efficiency measures.

UNIT-IV: Management of farm resources ï Land, Labour, Farm machinery, Farm building, etc.

UNIT-V: Risk and uncertainty in farming ïsources of uncertainty in farming, management strategy to counteract uncertainty and decision making process in farm business management under risks and uncertainty.

Suggested Readings


ABM 522 SEED PRODUCTION TECHNOLOGY AND MANAGEMENT 2+0

(To be taught by Seed Science and Technology)

Objective

To apprise students regarding principles and efficient management of seed production technology.

Contents

UNIT-I: Seed Technology ï Role of Seed Technology, Seed Industry in India, National Seed Corporation ï Tarai Seed Development Corporation, State Seed Corporations, National Seed Project and State Farms and their role.

UNIT-II: Development and Management of Seed Programmes ï Seed Village Concept, Basic Strategy of Seed Production and Planning and Organization of Seed Programme; Types of Seed Programme ï Nucleus seed, Breeders seed, Foundation seed and Certified seed etc.
UNIT-III: Maintenance of genetic purity – Minimum seed certification standard and Management of breeders & Nucleus seed; Management of seed testing laboratory and research and development.

UNIT-IV: Management of seed processing plant, seed storage management; seed packaging and handling.

UNIT-V: Statutory intervention in the seed industry; Seed legislation and seed law enforcement, Seed act; Orientation and visit to seed production farms, seed processing Units, NSC, HSDC, etc.

Suggested Readings

ABM 523 TECHNOLOGY MANAGEMENT FOR LIVESTOCK PRODUCTS 2+0
(To be taught by Livestock Products Technology)

Objective
To impart knowledge about management of livestock products, product development, quality control, preservation and marketing strategies for livestock products.

Contents
UNIT-I: Present status of livestock products industry in India – dairy, meat poultry, skin, wool, etc; Dairy Products- Manufacturing technologies of various dairy products and by-product utilization.
UNIT-II: Meat and Poultry Products- Manufacturing technologies of meat and meat products, egg and poultry products; production processing and utilization of wool and animal by-products.
UNIT-III: Plant Management- Production planning and control needs and techniques of production control, packaging, preservation and storage system for livestock products; transportation system for domestic markets and international markets.
UNIT-IV: Quality control measures during storage and transit; extent of losses during storage and transport, management measures to minimize the loss.
UNIT-V: Marketing and distribution of animal products; quality standard for various products; environmental and legal issues involved.

Suggested Readings
Mountney GJ. *Poultry Products Technology*. 2nd Ed. AVI Publ.

ABM 524 FRUIT PRODUCTION AND POST HARVEST MANAGEMENT 2+0
(To be taught by Fruit Science)

Objective
To impart knowledge regarding agro-techniques of fruit crops and their post-harvest management.
ABM 525  FARM POWER & MACHINERY MANAGEMENT  2+0
(To be taught by Farm Machinery and Power Engineering)

Objective
To acquaint the students with the farm mechanization status in the country and various techniques for farm machinery management and marketing.

Contents
UNIT-I: Various sources of farm power, their availability and utilization; Course Objective, importance and present status, level and the scope of farm mechanization.
UNIT-II: Tractor and power tillage industry; model, make, capacity, production, present status and future prospects; concept of zero tillage.
UNIT-III: Farm machinery selection for different size of farm size and for different agro-climatic conditions; scheduling of farm operations for higher efficiencies, indices of machine performance.
UNIT-IV: Cost analysis of operations using different implements, economic performance of machines, optimization of tractor implements system and transport of farm produce.
UNIT-V: Agricultural equipments industry; their production, marketing and constraints; establishment of agricultural engineering enterprises.

Suggested Readings
UNIT-V: Market entry methods, export procedures & documentations.

Suggestive Readings
Economic Survey of India. Ministry of Finance, Govt. of India. (various issues)
HAU 2003. Refresher Course on Technological Interventions to Face WTO Challenges.
AAREM & HRD CCS HAU Hisar.
Indian Journal of Agricultural Economics

ABM 527 MANAGEMENT OF AGRIBUSINESS COOPERATIVES 2+0
Objective
To provide the students an understanding about the agribusiness cooperative organizations and their management.

Contents
UNIT-I: Cooperative administration- a global perspective, ecology of cooperative administration, cooperative sector and economic development.
UNIT-II: Cooperative management- nature, functions and purpose of cooperatives ï procurement, storage, processing, marketing, process of cooperative formation, role of leadership in cooperative management.
UNIT-III: The state and cooperative movement, effects of cooperative law in management, long range planning for cooperative expansion, policy making.
UNIT-IV: Human resource management, placement and role of board of directors in cooperative management.
UNIT-V: Overview of agribusiness cooperative ï credit cooperatives, cooperative marketing, dairy cooperative; financing agribusiness cooperatives.

Suggested Readings

ABM 528 AGRIBUSINESS FINANCIAL MANAGEMENT 2+0
Objective
To impart trainings to the students regarding various aspects of financial management for agribusiness.

Contents
UNIT-I: Importance, need and scope of financial management; classification and credit need in changing agriculture scenario; finance functions, investment and dividend functions; balance sheet, income statement, cash flow statement for a agribusiness unit.
UNIT-II: Financial planning and control ï assessment of financial requirement of a agribusiness unit; leverage ï concept of leverage, financial and operating leverage; factor affecting capital structure, features of an optimal capital structure.
UNIT-III: Working capital management ï concept and components of working capital, need for working capital in agribusiness, management of cash and accounts receivables, and inventory management for agribusiness.
UNIT-IV: Capital budgeting - steps and concept of capital budgeting, appraisal criteria ï payback period, average rate of return, net present value, benefit-cost ratio and internal rate of return.
UNIT-V: Agri-business financing system in India - functioning of cooperative credit institutions, commercial banks, regional rural banks, NABARD, Agro-Industries Corporation, etc in agribusiness financing.

Suggested Readings
ABM 529  FOOD RETAIL MANAGEMENT  2+0

Objective
The objective of this course is to assist students in understanding the structure and working of food marketing system in India, to examine how the system affects farmers, consumers and middlemen and to illustrate the response of this dynamic marketing system to technological, socio-cultural, political and economic forces over time.

Contents
UNIT-I: Retail management and Food Retailing, Organized Retailing in India, E-tailing and Understanding food preference of Indian Consumers, Food consumption and Expenditure pattern, Demographic and Psychographic factors affecting Food Pattern of Indian Consumer.
UNIT-II: Value Chain in Food Retailing, Principal trends in food wholesaling and retailing, the changing nature of food stores, various retailing formats, value chain and value additions across the chain in food retail.
UNIT-III: 4 P's in Food Retail Management, Brand Management in Retailing, Merchandise pricing, Pricing Strategies used in food retailing, Promotion mix for food retailing, Management of sales promotion and Publicity, Advertisement Strategies for food retailers.
UNIT-IV: Managing Retail Operations, Managing Retailers' Finances, Merchandise buying and handling, Merchandise Pricing, Logistics, procurement of Food products and Handling, Transportation of Food Products.
UNIT-V: Types of Retail Selling, Salesperson selection, Salesperson training, Evaluation and Monitoring, Customer Relationship Management, Managing Human Resources in retailing

Suggested Readings

ABM 530  MANAGEMENT OF AGRICULTURAL INPUT MARKETING  2+0

Objective
The objective of this course is to give the students an understanding of different marketing concept and marketing system in context of agricultural inputs.

Contents
UNIT-I: Agricultural input marketing - meaning and importance; Management of distribution channels for agricultural input marketing; Agricultural Inputs and their types - farm and non-farm, role of cooperative, public and private sectors in agri- input marketing.
UNIT-II: Seed- Importance of seed input; Types of seeds- hybrid, high yielding and quality seeds; Demand and supply of seeds; Seed marketing channels, pricing, export-import of seeds; Role of NSC and State Seed Corporations.
UNIT-III: Chemical Fertilizers- Production, export-import, supply of chemical fertilizers, Demand/consumption, Prices and pricing policy; subsidy on fertilizers; marketing system of marketing channels, problems in distribution; Role of IFFCO and KRIBCO in fertilizer marketing.
UNIT-IV: Plant Protection Chemicals- Production, export/import, consumption, marketing system of marketing channels; Electricity/Diesel Oil- marketing and distribution system; pricing of electricity for agriculture use; subsidy on electricity.
UNIT-V: Farm Machinery- Production, supply, demand, Marketing and distribution channels of farm machines; Agro-industries Corporation and marketing of farm machines/implements.

Suggested Readings
ABM 531  FEED BUSINESS MANAGEMENT  2+0
(To be taught by Animal Nutrition)

Objective
To acquaint the students with the role and importance of feed industry and the production of feed for livestock and poultry.

Contents
UNIT-I: Present status of feed resources; gap between demand and availability of nutrients; status of feed industry in India and world, constraints in the development of Indian feed industry.
UNIT-II: Nutrients requirements of livestock and poultry; feed stuff and their origin; scientific storage of feeds and feed ingredients; protection of protein and fat.
UNIT-III: Processing of feeds, layout and design of feed plants, feed plant management; feed preparation for fish and pet animals, specialty feeds.
UNIT-IV: Importance and preparation of mineral mixture; feed additives and supplements, feed mixing, principles of mixing and compounding of feeds; improving the feeding value of poor quality roughages.
UNIT-V: Distribution channels, regulations relating to manufacture and sale of feed stuffs.

Suggested Readings
Gohl BO. 1981. Tropical Feeds. FAO.

ABM 532  AGRI SUPPLY CHAIN MANAGEMENT  2+0

Objective
The course introduces students to the concepts and processes of agricultural supply chain management, framework for structuring supply chain drivers; network designs, demand forecasting, inventory planning, sourcing decisions and IT enablement of supply chain.

Contents
UNIT-I: Supply Chain Management ñ Concept, need, and significance; Evolution of SCM; SCM Approach; Traditional Agri. Supply Chain Management Approach; Modern Supply Chain Management Approach; Elements in SCM.
UNIT-II: Demand Management in Supply Chain; Types of Demand, Demand Planning and Forecasting; Operations Management in Supply Chain.
UNIT-IV: Logistics Management: Elements of Logistics ; Distribution Management, Distribution Strategies; Pool Distribution; Transportation Management ; Fleet Management ; Service Innovation; Warehousing; Packaging for Logistics, Third-Party Logistics (TPL/3PL)
UNIT-V: Concept of Information Technology: IT Application in SCM; Advanced Planning and Scheduling; Performance Measurement and Controls in Agri. Supply Chain Management- Benchmarking: introduction, concept and forms of Benchmarking.

Suggested Readings
ABM 533  POUlTRy AND HATCHERY MANAGEMENT  2+0
(To be taught by Livestock Production Management)

Objective
The course provides an insight into the importance of management in poultry industry, managing a poultry and hatchery enterprise, planning production of poultry products, financial, personnel and marketing management.

Contents
UNIT-I: Poultry and hatchery industry; role of management in poultry industry.
UNIT-II: Planning and establishing a poultry and hatchery unit - location, size and construction; farm and hatchery equipments and physical facilities; organizing and managing a poultry farm and hatchery.
UNIT-III: Incubation and hatching; production of quality chicks and eggs; factors affecting hatchability; bio-security and hatchery sanitation; handling of hatching eggs; maintaining chick quality-chick grading, sexing, packing, dispatch, transportation and chick delivery.
UNIT-IV: Franchise hatcheries; custom hatching; brooding; growing and laying management; industrial breeding, feeding, housing and disease management; waste management; Record management; cost accounting and budgetary control.
UNIT-V: Risks and insurance; personal management - labour relations including wages and salaries, job evaluation and employee appraisal; marketing management-direct sale and sale through franchisees/agents, advertisement, sale and after sale services, other innovative sales strategies.

Suggested Readings

ABM 534  MANAGEMENT OF FLORICULTURE AND LANDSCAPING  2+0
(To be taught by Floriculture and Landscape Architecture)

Objective
To objective of this course is to expose the students with floriculture technology and its Agri business implications including international trade.

Contents
UNIT-I: Introduction, importance and scope of floriculture industry; Recent advances in floriculture industry.
UNIT-II: Drying and dehydration of flowers; response of flowers to environmental conditions; importance and scope of landscape gardening.
UNIT-III: Style of gardening, Anesthetic and Socio-aesthetic planning of old and newly developed towns and cities; commercial cultivation of flower crops (rose, jasmine gladiolus, tuberose, marigold, aster, carnation, gerbera, cillum chrysanthemum; use of plant regulators in flower production.
UNIT-IV: Extraction, purification and storage of essential oils and perfumes; post harvest changes in cut flowers, storage and packing of cut flowers; determining optimum time of harvesting of flowers for export and home use.

Suggested Readings

ABM 535/ FST 533  BUSINESS MANAGEMENT & INTERNATIONAL TRADE  3+0

Objective
To acquaint the students with concepts, areas, functions and techniques of Business Management & International Trade in the context of food sector.

Contents
UNIT-I: The concept of business, trade, industry, firm and management; functions of management; areas of management; concept and functions of marketing; scope of
marketing management; marketing mix; marketing organizational structure; micro and macro environments; consumer behaviour; consumerism; marketing research and marketing information systems.

UNIT-II: Market measurement- present and future demand; Market forecasting; market segmentation, targeting and positioning; Allocation of marketing resources; Marketing Planning Process; Product policy and planning; Product-mix; product line; product life cycle; New product development process; Branding, packaging, services decisions; Marketing channel decisions: Retailing, wholesaling and distribution; Pricing Decisions: Price determination and pricing policy of milk products in organized and unorganized sectors of dairy industry.

UNIT-III: Promotion mix decisions, Advertising: functions, objectives, and types; advertising budget and advertising message; Media Planning; Personal Selling; Publicity; Sales Promotion; Food and Dairy Products Marketing.

UNIT-IV: International Marketing and International Trade; Salient features of International Marketing; Composition & direction of Indian exports; International marketing environment; Deciding which & how to enter international market; Exports-Direct exports, indirect exports, Licensing, Joint Ventures, Direct investment & internationalization process; Deciding marketing Programme; Product, Promotion, Price, Distribution Channels; Deciding the Market Organization; World Trade Organization (WTO).

Suggested Readings

MBA (General)

FINANCE

MGT 516 WORKING CAPITAL MANAGEMENT 2+0

Objective
To impart knowledge about the concept, importance and management of working capital in an organization.

Contents
UNIT-I: Working Capital Management: Concept of Working Capital Management, Liquidity Vs Profitability trade off, Decision towards optimum working capital, Calculation of operating working capital
UNIT-II: Management of Cash: objective of cash management, Motives for holding cash, Preparation of the cash budget, Managing the cash flows, Reasons for investing in marketable securities.
UNIT-III: Management of Account Receivables: Optimum credit policy, Terms of credit, Credit procedures for individual accounts, Credit analysis and Credit control. Factoring services and its types.
UNIT-IV: Inventory Management: Benefits of holding inventory, Inventory management techniques, Inventory control techniques.

Suggested Readings

MGT 517 DIRECT TAX LAWS 2+0

Objective
To impart knowledge about the concept, importance and calculation of direct tax.
Contents
UNIT-I: Concept of Previous Year, Assessment Year, Income, Total Income, Gross Total Income.
UNIT-III: Residential Status and incidence of Tax: Heads of Income-Salary, House Property, Business, Profession; Capital Gains and Other Sources
UNIT-IV: Set off and Carry forward of Losses; Deductions for individuals, Assessment of Individuals.
UNIT-V: Procedure of Filing Tax Return, Payment of Advance Taxes, Tax Deduction at Source.

Suggested Readings

MGT 518  FINANCIAL INSTITUTIONS  2+0
Objective
To impart knowledge about the various financial institutions and their functioning.

Contents
UNIT-I: Commercial Banks: Definition, Services and Principles of commercial banks, Nationalization of commercial banks ï Objects, Achievements and Criticism, Changing profile of Indian banking
UNIT-II: Practical banking: accounts of customers, Cheques: requisites of cheques crossing and endorsement, refusal of cheque payment by bank, Relation Between Banker and Customer
UNIT-III: Nature of Primary Reserves-its Nature and Functions; Nature of Secondary Reserves ï factors influencing the Level of Secondary Reserves
UNIT-V: Financial Institutions: Functions and Objectives of IDBI, SFC, NABARD, ICICI, SIDBI, LIC, and UTI.

Suggested Readings
Jeff Madura. Financial Institutions and Market. 7th Ed. 2007, Thomson South Western.

MGT 519  STOCK MARKET OPERATIONS  2+0
Objective
To impart knowledge about the functioning of Indian stock market in our financial system

Contents
UNIT-II: Money and capital markets, money market instruments: call money, treasury bills, certificate of deposit, commercial bills, trade bills; Capital market: Brief profile of NSE, BSE, and OTCEI. Functions and organization of stock exchange.
UNIT-III: Primary/Secondary Market: Role, Procedure of raising finance, SEBI-role and Constitution;
UNIT-IV: Grievances Concerning Stock Exchange Dealings and their Removal, Grievance Cells in Stock Exchange
UNIT-V: Mutual Funds: Introduction, types, SEBI guidelines for Mutual Funds in India, Suggestions to make more effective.

Suggested Readings
Avadhani VA. Investment and Securities Market in India. 4th Ed. Himalaya Publ.
Machiraju HR. The Working of Stock Exchanges in India. 2nd Ed. New Age International.
MGT 520  MERCHANT BANKING AND FINANCIAL SERVICES MANAGEMENT  2+0

Objective
To impart knowledge about the concept and functions of different financial services in different areas of finance

Contents
UNIT-I: Concept, Nature and Scope of Financial Services, Participants of Financial Service, introduction to financial market;
UNIT-II: Leasing and Hire Purchase: Introduction to Leasing, Types of Lease, Myths about Leasing, prospects of leasing industry. Meaning of Hire Purchase, Contents of Hire Purchase Agreement, difference between leasing and hire-purchase;
UNIT-IV: Factoring and Merchant Banking: Factoring: Meaning and Types of Factoring Arrangements; Merchant Bankers: Functions of Merchant Bankers, Mode of Raising Capital from primary market, Role of secondary market. Recent developments in the Indian primary market and secondary market,
UNIT-V: Credit Rating Agencies: Concept and Types of Credit Rating Agencies. SEBI: functions and role in settlement of investors’ problems.

Suggested Readings

MGT 521  SECURITY ANALYSIS & PORTFOLIO MANAGEMENT  2+0

Objective
To impart knowledge about the concept and different theories of investment and portfolio

Contents
UNIT-II: Securities Analysis: Analysis for Equity Investment I Fundamental Analysis, Company Level Analysis, Economy and Industry Analysis.
UNIT-IV: Portfolio Theory traditional and modern portfolio theory Markowitz and Sharpe model for Portfolio construction.
UNIT-V: Capital Market Theory: CAPM, APT.

Suggested Readings
Bhalla VK. Investment Management : Security Analysis And Portfolio Management. 11th Ed. S.Chand & Co.

MGT 522  INTERNATIONAL FINANCIAL MANAGEMENT  2+0

Objective
To impart knowledge about the International economic issues, financial flows, institutions and instruments.

Contents
UNIT-II: Balance of Payment Framework; Foreign Exchange Risk Management: Foreign Exchange Market and Instruments, Exchange Rate-Determination & Forecasting.
UNIT-IV: International financial Institutions and Instruments: IBRD, IMF, IFC- their Objectives and functions.
UNIT-V: International Financial Instruments-Swaps, hedging, options, G.D.R., A.D.R.
MGT 523

MANAGEMENT CONTROL SYSTEM

Objective
To impart knowledge about the concept, importance and management of control system

Contents
UNIT-I: Meaning and concept of Management control, types of control: organization control, strategic control, formal versus informal control, process of control, Introduction to management control system, and prerequisites of an effective management control system;
UNIT-II: Delegation and decentralization of authority- reasons of delegation, forms of delegation, factors determining delegation,
UNIT-III: Profit centre: definition, role of a profit center, the concept and methods of transfer pricing; Investment centre: Profit vs investment centre, performance measurement of an investment center,
UNIT-IV: Budget and budgetary control-meaning and types of budgets, performance budgeting, zero based budgeting;
UNIT-V: Performance evaluation-concept and need criteria for performance evaluation, reporting of performance

Suggested Readings
Macariello &Kirby, Management Control Systems: Using Adaptive Systems to Attain Control. 2nd Ed. PHI Learning.

MARKETING MANAGEMENT

MGT 524

SALES MANAGEMENT

Objective
The objective of this course is to acquaint students with the techniques of managing sales force and sales task of the company.

Contents
UNIT-I: The Field of Sales Management, Objectives and Functions of Sales Management, Evolution of Professional Selling, Relationship of Marketing and Selling, Functions and Role of Sales Manager
UNIT-II: Organization structure for sales department, Estimating Manpower Requirements for Sales department, Devising Sales Territories, Routing and Scheduling of Sales Force
UNIT-III: Recruitment and Selection of sales force, Training and Development, Placement and Induction of sales force, Motivating Sales Force
UNIT-IV: Compensation and Promotion Policies for sales people, Performance Appraisal of sales force
UNIT-V: Sales Budget and Budgeting Procedure, Quota Setting and Administrating, Sales and Cost Analysis, Sales Records and Reporting System, Sales Meetings and Contests.

Suggested Readings
MGT 525  MARKETING RESEARCH  2+0

Objective
The objective of this course is to acquaint students with the tools and techniques of marketing research. The focus will be to impart practical knowledge of conducting marketing research right from selection of problem till analysis and interpretation of data.

Contents
UNIT-I: Marketing Research- Nature, Scope, Importance, Process, Types and Limitations, Marketing Research and Marketing Information System
UNIT-II: Research Design-Concept and Steps in Developing a Research Design; Types of Errors Affecting Research Design, Choosing a Research Design
UNIT-III: Concepts of Universe and Sample, Techniques of Sampling, Type of scales and their uses.
UNIT-IV: Methods and Instruments of Data Collections, Techniques for Data Analysis, Testing of Hypothesis
UNIT-V: Product Research, Sales Research, Advertising Research; Organization and Management of Marketing Research Department, Ethical Issues in Marketing Research.

Suggested Readings

MGT 526  CONSUMER BEHAVIOUR  2+0

Objective
The objective of this course is to expose students to the concepts and factors that influence consumer behaviour.

Contents
UNIT-I: Consumer Behavior- Concept and Importance, Need to Study Consumer Behavior, Consumer Needs and Motivations, Perception, Personality and Attitudes, Learning, Consumer Attitude Formation and Change
UNIT-II: Group Dynamics, Consumer Reference Groups-family, Social Class, Influence of Culture on Consumer Behavior, Sub-Cultural Aspects of Consumer Behavior
UNIT-III: Consumer decision-making process, opinion leaders, diffusion of innovations, innovator as opinion leader; Different views of decision making-economic man, passive man, cognitive man, emotional man
UNIT-IV: Models of consumer decision-making like Howard Seth, Nicosia and Engel Blackwell models etc.
UNIT-V: Public policy and Consumer Protection, Consumerism and Role of Media.

Suggested Readings

MGT 527  INTERNATIONAL MARKETING  2+0

Objective
The objective of this course is to expose students to the concept, need, methods and significance of international marketing.

Contents
UNIT-I: International Marketing-Nature, Scope and Importance, International Marketing Tasks, Market Entry Methods
UNIT-II: International Marketing Environment, Influence of Culture and Sub Culture, Tariff & non-tariff barriers
UNIT-III: International Product Policy, Planning and Development of Products for Foreign Markets
UNIT-IV: Pricing in International Markets, Pricing Objectives, and Determination of Pricing Policies and Strategies
UNIT-V: Types of International Distribution Channels- Selecting and Managing Distribution Channels, International promotion, Developing the Promotion-Mix for foreign Markets.

Suggested Readings

MGT 528 ADVERTISING MANAGEMENT 2+0
Objective
The objective of this course is to impart the knowledge of creating an advertisement and releasing it in media.

Contents
UNIT-I: Advertising-Concept, Scope, Objectives, Types and Functions, Role of Advertising in marketing Mix, Advertising Versus other Tools of Promotions
UNIT-II: Advertising Planning and Decision-Making, Setting Goals and Objectives, Advertising Appeals and Theme, Message Tactics- Attention and Communication
UNIT-III: Elements of a Copy, Process of Copy Writing, Creativity in Copy Writing, Layout of Copy
UNIT-IV: Copy Testing-Techniques; Media Strategy and media Choice, Scheduling and Timing Decisions for Advertising
UNIT-V: Organizational structure and functions of an advertising agency, social responsibility of advertising.

Suggested Readings

MGT 529 RETAIL MANAGEMENT 2+0
Objective
The objective of this course is to expose students to the field of retailing. The focus will be to impart knowledge of setting up and running a retail business.

Contents
UNIT-I: Retailing-Definition, Role and Importance, Evolution of Retail Institutions, Types of Retailers, Challenges for Retail Managers
UNIT-II: Retail Strategy Formulation, Retailing Mix, Latest Trends in Retailing Store Development I Financial Planning, Site Selection, Store Design, Store Organization, Store Layout, and Staffing
UNIT-III: Merchandising Planning, Merchandise Resources, Pricing, Distribution and Control, Retail Promotion-Advertising, Publicity and sales promotion, Retail Display
UNIT-IV: Introduction to Non-Store Retailing - Direct Mail, Catalogues, Tele-Marketing, Electronic Retailing, Kiosks, Franchising;
UNIT-V: Retail Credit and Customer Services, Relationship Marketing; Retail Security, Operations Control, Expenses and Performance Control, Retail Audit.

Suggested Readings

MGT 530  PRODUCT MANAGEMENT  2+0

Objective
The objective of this course is to expose students to different facets of product and brand management.

Contents
UNIT-I: Concept and importance of product management, product management processes, Product portfolio
UNIT-II: Product line decisions, product life cycle, new product development
UNIT-III: Product positioning, positioning strategies, branding decisions, brand management, brand hierarchy
UNIT-IV: Brand personality, brand equity, measurement of brand equity, brand extensions
UNIT-V: Packaging and labeling decisions, launching the product, test marketing, Product failures.

Suggested Readings
Majumdar. Product Management in India. PHI.

MGT 531  STRATEGIC MARKETING  2+0

Objective
The objective of this course is to impart knowledge of tools and techniques of strategic marketing to students

Contents
UNIT-I: Strategic marketing – Concept, scope, and relevance, significance and challenges for strategic marketing.
UNIT-II: Strategic planning, SWOT analysis, BCG and GE matrix.
UNIT-III: Marketing strategies for market leaders, challengers, followers, and nichers
UNIT-IV: Segmentation and competitive advantage, Product differentiation, Targeting and brand positioning
UNIT-V: Competitive pricing; Competitive advertising, Role of sales promotion in competitive marketing, Competitive distribution.

Suggested Readings

HUMAN RESOURCE MANAGEMENT

MGT 532  ORGANISATIONAL DEVELOPMENT AND INTERVENTION  2+0

STRATEGIES

Objective
The objective of this course is to impart knowledge of the concept and techniques of organizational development and also to expose students to intervention strategies.

Contents
UNIT-I: Organisational development- history of organisational development, nature, characteristics, assumptions and process.
UNIT-II: Issues and challenges for OD practitioners-organisational value system, politics & OD, OD & strategic management, OD & quality movement.
UNIT-III: OD interventions-definition, types, person focused OD interventions, role focused interventions, personal, interpersonal and group interventions.
UNIT-IV: Comprehensive interventions, structural interventions, inter-group interventions, mirror interventions, process consultation.
UNIT-V: Transactional analysis, team building.

Suggested Readings
Allcorn. Organisational Dynamics & Interventions. PHI.

MGT 533 UNION MANAGEMENT RELATIONS 2+0

Objective
The objective of this course is to acquaint students with the intricacies of union management relations.

Contents
UNIT-I: Conceptual frame work- Concept, Scope and approaches to industrial relations, Evolution and current developments, Constitutional and Legal Framework of Industrial Relations
UNIT-II: Union and unionism- trade union development and functions, trade union structure and trade union recognition, leadership and management in the trade union, management and employers’ association
UNIT-III: Conflict resolution- dynamics of conflict and collaboration, nature and content of collective bargaining, negotiation skills, issues and trends in collective bargaining
UNIT-IV: Grievance Function in Industrial Relations, Role of labour conciliation, arbitration, and adjudication
UNIT-V: Workers’ participation in management- evolution, structure and process, design and dynamics of participatory forms, strategies and planning for implementing participation.

Suggested Readings
Monappa A. Industrial Relations. McGraw Hill.

MGT 534 INDUSTRIAL PSYCHOLOGY 2+0

Objective
The objective of this course is to acquaint students with the concept and significance of Industrial psychology.

Contents
UNIT-I: Introduction to industrial psychology, historical background of industrial psychology in India
UNIT-II: Human performance and engineering psychology; The psychology of attitudes, frustration as a factor in behaviour, supervisory and executive leadership, motivation & work
UNIT-III: Personnel selection- occupational information, individual differences-techniques, interviews, psychological tests
UNIT-IV: Industrial accidents & their prevention- measures for safety
UNIT-V: Psychological factors in labour turnover, counseling, interviewing & improving job contents.

Suggested Readings

MGT 535 COMPENSATION MANAGEMENT 2+0

Objective
The objective of this course is to expose students to the concept and techniques of Compensation Management

Contents
UNIT-I: Compensation- compensation and rewards and their role in organisations, Economic and behavioural issues in compensation
UNIT-II: Constitutional and legal framework for wage legislation-constitutinal framework and judicial norms of wage determination, international conventions and regulations, Law relating to Payment of Wages and Bonus, Regulation of Minimum Wages and Equal Remuneration
UNIT-III: Compensation structure and differentials- pay packet composition, wage determination, job evaluation, pay surveys
UNIT-IV: Reward system, incentives and pay restructuring- design of performance linked reward system, incentives for blue and white collars, bonus, profit sharing and stock options, allowances and benefits, pay restructuring in mergers, acquisitions and alliances
UNIT-V: Emerging issues and trends- compensation for executives and knowledge workers, tax planning, future trends in compensation management.

Suggested Readings
Goel. Performance Appraisal & Compensation Management. PHI.

MGT 536 ORGANISATIONAL CHANGE AND STRESS MANAGEMENT 2+0
Objective
The objective of this course is to acquaint students with the concept and techniques of organizational change and also of stress management.

Contents
UNIT-I: Concept of managing change- Types of Change, factors critical to change, process of organisational change, key roles in organisational change, culture and change, managing resistance to change, effective implementation of change
UNIT-II: Forms of organizational change I emerging organizational forms and structures, turn around management, mergers and acquisitions, process based change, group based approaches to change
UNIT-III: Diagnosis and intervention- issues and concept of organisational diagnosis, diagnostic methodology and methods (qualitative and quantitative), intervention in organisational change
UNIT-IV: Organisational change and process consultation- Key roles in managing change, skills for managing change, role of leadership in managing change, managing transition.
UNIT-V: Understanding stress- potential sources of stress, consequences of stress, managing stress, current models of stress management

Suggested Readings

MGT 537 LABOUR ECONOMICS 2+0
Objective
The objective of this course is to acquaint students with the concept and issues of labour economics.

Contents
UNIT-I: Introduction to labour market, Actors in labour market, labour supply, labour supply and business cycle, Industrial development and growth of labour.
UNIT-II: Economic analysis of labour markets, Demand and supply of labour, Public policy and labour issues
UNIT-IV: Labour market discrimination, Race and gender discrimination, Employer discrimination, Issues related to women and child labour
UNIT-V: Labour migration, Immigration to foreign countries, Issues of labour training and unemployment

Suggested Readings
Borjas GJ. Labour Economics. 3rd Ed. McGraw Hill.

MGT 538 INDUSTRIAL AND LABOUR LEGISLATION 2+0
Objective
The objective of this course is to expose students to various industrial and labour laws.

Contents
UNIT-I: Introduction to labour legislation- philosophy of labour laws, classification of labour laws, International labour organization, international labour standards and Indian labour laws, Indian constitution and labour laws, labour policy.

Suggested Readings
Padhi. Labour & Industrial Laws. PHI.

MGT 539 STRATEGIC HUMAN RESOURCE MANAGEMENT 2+0

Objective
The objective of this course is to expose students to the concept and utility of strategic human resource management.

Contents
UNIT-I: Strategic role of human resource management- concept, nature & origin, linking organizational and HR strategies, strategic human resource in global context.
UNIT-III: Organizational structuring and restructuring- new organizational forms and implications for strategic human resource management, employment relations in changing context.
UNIT-V: Technology and HRM, Human Resource Information System, Knowledge Management.

Suggested Readings
Schuler Strategic Human Resource Management. 2nd Ed. Wiley India.
List of Journals

- Agribusiness ï An International Journal
- Decision
- Harvard Business Review
- Indian Cooperative Review
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Finance
- Indian Journal of Marketing
- Indian Management
- Indian Management Studies Journal
- Journal of Agri-business
- Journal of Marketing Management
- Journal of Marketing Research
- Journal of Sales Management
- Management Review
- Prabandhan
- Vikalpa

e - Resources

- www.pearsoned.com (Pearson Education Publication)
- www.aima-ind.org (All India Management Association)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage Publications)
- www.marketingpower.com (American: Marketing Association)
- www.isaaindia.org (Indian Society of Agricultural Economics)
- www.macmillanindia.com (Mac Millan Publishing)
- www.sfacinidia.com (Small Farmers Õ Agri-Business Consortium)
- www.isapindia.org (Indian Society of Agribusiness Professionals)
- www.icar.org.in (Indian Council of Agricultural Research)
- www.nseindia.com (National Stock Exchange of India Ltd)
- www.nseindia.com (Bombay Stock Exchange)
- www.ncdex.com (National Commodity & Derivatives Exchange Limited)
- www.phdcci.in (PHD Chamber of Commerce and Industry)
- www.ficci.com (Federation of Indian Chambers of Commerce and Industry)
- www.assocham.org (Associated Chambers of Commerce and Industry of India)
- www.apeda.com (Agricultural and Processed Food Products Export Development Authority)
- www.mpeda.com (Marine Products Export Development Authority)
## Course Structure

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SERVICE COURSES

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*Compulsory for Master's programme; ** Compulsory for Doctoral programme
*One out of 511 or 512 is compulsory
One course of Biochemistry or G&PB of 3 credits is compulsory as Minor/Supporting

To be taught by: ❶ Nematology; ❷ Entomology; ❸ Entomology and Plant Pathology
ENTOMOLOGY

Course Contents

ENT 501  INSECT MORPHOLOGY  1+1  SEM - I

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

Theory
UNIT-I: Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.
UNIT-II: Head- Origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites.
UNIT-III: Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications.
UNIT-IV: Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemo-receptors).

Practical
Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Sense organs.

Suggested Readings

ENT 502  INSECT ANATOMY, PHYSIOLOGY  2+1  SEM - II

Objective
To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

Theory
UNIT-I: Scope and importance of insect anatomy and physiology.
UNIT-II: Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.
UNIT-III: Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause.
UNIT-IV: Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular micro-organisms and their role in physiology; artificial diets.

Practical
Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Suggested Readings
ENT 503/ NEMA 502
(PRINCIPLES OF TAXONOMY) 2+0 SEM - I

(To be taught by Nematology)

Objective
To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory
UNIT-I: Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods- character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.

UNIT-II: Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.


Suggested Readings

ENT 504
(CLASSIFICATION OF INSECTS) 2+1 SEM - II

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

Theory
UNIT-I: Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda ï Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.


UNIT-III: Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Division Neoptera ï Subdivision Endopterygota, Section Neuropteroïd-Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

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

Suggested Readings

**ENT 505 INSECT ECOLOGY**

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

**Theory**


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

ENT 506 INSECT PATHOLOGY 1+1 SEM - II
Objective
To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence; provide hands-on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

Theory
UNIT-I: History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.
UNIT-II: Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Practical

Suggested Readings

ENT 507 BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS 1+1 SEM - I
Objective
To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory
UNIT-I: History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control-importation, augmentation and conservation.
UNIT-II: Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects.
UNIT-III: Mass production of quality biocontrol agents—techniques, formulations, economics, field release/application and evaluation.

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

Suggested Readings

ENT 508 TOXICOLOGY OF INSECTICIDES 2+1 SEM - II

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

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

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

Suggested Readings

**ENT 509**

**PLANT RESISTANCE TO INSECTS**

1+1 SEM - 1

**Objective**

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management.

**Theory**

UNIT-I: History and importance of resistance, principles, classification, components, types and mechanisms of resistance.
UNIT-II: Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.
UNIT-III: Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance.
UNIT-IV: Factors affecting plant resistance including biotypes and measures to combat them.
UNIT-V: Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.
UNIT-VI: Role of biotechnology in plant resistance to insects.

**Practical**

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

**Suggested Readings**

Panda N & Khush GS. 1995. Plant Resistance to Insects. CABI.

**ENT 510/ NEMA 512**

**PRINCIPLES OF INTEGRATED PEST MANAGEMENT**

1+1 SEM - 1

**Objective**

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

**Theory**

UNIT-I: History and origin, definition and evolution of various related terminologies.
UNIT-II: Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.
UNIT-III: Tools of pest management and their integration- legislative, cultural, biological, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.
UNIT-IV: Components, classification, bases and mechanisms of host plant resistance; screening techniques, breeding methods including transgenics and importance of plant resistance in IPM.
Practical
Characterization of agro-ecosystems; demonstration of plant resistance in important crops; crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Readings

ENT 511 PESTS OF FIELD CROPS 1+1 SEM - 1

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

Theory
Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors.

UNIT-I: Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.).

UNIT-II: Insect pests of pulses, tobacco, oilseeds and their management.

UNIT-III: Insect pests of fibre crops, forages, sugarcane and their management.

Practical
Field visits, collection and identification of important pests and their natural enemies; study of life history of important insect pests.

Suggested Readings
Nair MRGK. 1986. *Insect and Mites of Crops in India*. ICAR.

ENT 512 PESTS OF HORTICULTURAL AND PLANTATION CROPS 1+1 SEM - 1

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

Theory
Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of pests of various crops.

UNIT-I: Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, ber, fig, citrus, aonla, pineapple, apple, peach and other temperate fruits.
UNIT-II: Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc.
UNIT-III: Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine etc.
UNIT-IV: Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation.

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

Suggested Readings

ENT 513 STORAGE ENTOMOLOGY 1+1 SEM - II

Objective
To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory
UNIT-I: Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-à-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses.
UNIT-II: Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.
UNIT-III: Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.
UNIT-IV: Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

Practical
Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them; detection of insect infestation in stored food grains; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).
Suggesting Readings


**ENT 514/ PL PATH 514 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS**

1+1 SEM - II

**Objective**
To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

**Theory**

UNIT-I: History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.
UNIT-II: Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.
UNIT-III: Transmission of plant viruses by aphids, whiteflies, mealybugs and thrips.
UNIT-IV: Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.
UNIT-V: Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

**Practical**
Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

**Suggested Readings**

Basu AN. 1995. *Bemisia tabaci* (Gennadius) - *Crop Pest and Principal Whitefly Vector of Plant Viruses*. Oxford & IBH.

**ENT 515 GENERAL ACAROLOGY**

1+1 SEM - II

**Objective**
To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

**Theory**

UNIT-I: History of Acarology; importance of mites as a group; habitat, collection and preservation of mites.
UNIT-II: Introduction to morphology and biology of mites and ticks. Broad classification-major orders and important families of Acari including diagnostic characteristics.
UNIT-III: Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens etc. Culturing of phytophagous, parasitic and predatory mites.

**Practical**
Collection of mites from plants, soil and animals and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

**Suggested Readings**

Objective
To impart knowledge about the different groups of arthropods found in soil, interaction between the different groups, and role of soil arthropods in humus formation. Hands-on training in sampling and identification of different groups of soil arthropods.

Theory
UNIT-I: Soil arthropods and their classification, habitats and their identification.
UNIT-II: Estimation of populations; sampling and extraction methods.
UNIT-IV: Harmful and beneficial soil arthropods and their management, inter-relationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical
Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; techniques and culturing soil invertebrates.

Suggested Readings

ENT 517 VERTEBRATE PEST MANAGEMENT 1+1 SEM - 1
Objective
To impart knowledge on vertebrate pests like birds, rodents, mammals etc., of different crops, their biology, damage they cause and management strategies.

Theory
UNIT-I: Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.
UNIT-II: Population dynamics and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds.
UNIT-III: Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods- Operational practices- baiting, bioassays (LD50 studies), equipments and educative programmes.

Practical
Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, control operation and preventive methods.

Suggested Readings
ENT 518 \hspace{1cm} TECHNIQUES IN PLANT PROTECTION \hspace{1cm} 0+1 \hspace{1cm} SEM - II

**Objective**
To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, electrophoresis etc.

**Theory**
UNIT-I: Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying, application through irrigation water.
UNIT-II: Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corns, cuttings and cut flowers.
UNIT-III: Use of irradiation, fumigation, soil sterilization and bird scaring techniques.
UNIT-IV: Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

**Suggested Readings**

ENT 519 \hspace{1cm} COMMERCIAL ENTOMOLOGY \hspace{1cm} 1+1 \hspace{1cm} SEM - I

**Objective**
To familiarize the students with entrepreneurial opportunities in entomology, provide information on productive insects and their products, as well as insect pests of public health and veterinary importance and their management.

**Theory**
UNIT-II: Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect- natural enemies and their management.
UNIT-III: Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect pests of cattle, poultry, pet animals and their management.

**Practical**

**Suggested Readings**
Singh S. 1975. *Beekeeping in India*. ICAR.
ENT 520/ NEMA 514/ PL PATH 520

PLANT QUARANTINE 2+0 SEM - II

Objective
To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory
UNIT-I: Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine of domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.
UNIT-III: Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.
UNIT-IV: WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

ENT 601 ADVANCED INSECT SYSTEMATICS 1+2 SEM - I
(Pre-requisite ENT 503)

Objective
To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

Theory
UNIT-III: Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN- Ethics.
UNIT-IV: Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications - small publications of species descriptions, 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.

Suggested Readings

**ENT 602**

**IMMATURE STAGES OF INSECTS**

**1+1**

**SEM - I**

**Objective**

To impart knowledge on morphology of immature stages of different groups of insects.

**Train students in identification of common pest species during their immature stages.**

**Theory**

UNIT-I: 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

UNIT-II: 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.

**Suggested Readings**


**ENT 603**

**ADVANCED INSECT PHYSIOLOGY**

**2+0**

**SEM - I**

(Pre-requisite ENT 502)

**Objective**

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

**Theory**

UNIT-I: Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization.

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

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

UNIT-IV: Endocrine system and insect hormones, physiology of insect growth and development- metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

**Suggested Readings**

Objective
To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics.

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

Practical

Suggested Readings
ENT 605 INSECT BEHAVIOUR 1+1 SEM - I
(Pre-requisite ENT 502)

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

Theory
UNIT-I: Defining Behaviour- Concept of Umwelt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.
UNIT-II: Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.
UNIT-III: Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Self-organization and insect behaviour.
UNIT-IV: Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

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.

Suggested Readings

ENT 606 RECENT TRENDS IN BIOLOGICAL CONTROL 2+0 SEM - II
(Pre-requisite ENT 507)

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

Theory
UNIT-I: Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents vis-à-vis target pest populations.
UNIT-II: Mass culturing techniques, insectary facilities and equipments, basic standards
of insectary, viable mass-production unit, designs, precautions, good insectary practices.

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

UNIT-IV: Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Suggested Readings

ENT 607 ADVANCED INSECTICIDE TOXICOLOGY 2+1 SEM - I

(Pre-requisite ENT 508)

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

Theory
UNIT-I: Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides.
UNIT-II: Biochemical and physiological target sites of insecticides in insects; developments in biorationalists, biopesticides and newer molecules; their modes of action and structural activity relationships; advances in metabolism of insecticides.
UNIT-III: Joint action of insecticides; activation, synergism and potentiation.
UNIT-IV: Problems associated with pesticide use in agriculture: pesticide resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.
UNIT-V: Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards, and good agricultural practices.

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

Suggested Readings

ENT 608 ADVANCED HOST PLANT RESISTANCE 1+1 SEM - II

(Pre-requisite ENT 509)

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

Theory
UNIT-I: Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources ï behaviour in relation to host plant factors.

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

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

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

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.

Suggested Readings

ENT 609 ADVANCED ACAROLOGY 1+1 SEM - I
(Pre-requisite ENT 515)

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

Theory

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

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

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

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.

Suggested Readings
**ENT 610**  
**AGRICULTURAL ORNITHOLOGY**  
1+1  
SEM - II

**Objective**
To expose the students to the prevalence of birds in agricultural fields, their habitat associations and the beneficial and harmful role played by birds in crop fields and management of pest situations.

**Theory**
**UNIT-I:** 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.


**Practical**
Study of different groups of birds associated with agriculture, their morphology and field identification. Field visits to different agro-ecosystems. 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.

**Suggested Readings**

**ENT 611**  
**MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH**  
1+1  
SEM - II

**Objective**
To familiarize the students with DNA recombitant technology, marker genes, transgenic plants, biotechnology in sericulture and apiculture.

**Theory**
**UNIT-I:** Introduction to molecular biology; techniques used in molecular biology.
**UNIT-II:** DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi.
**UNIT-IV:** Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.
**UNIT-V:** DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; *Sf* transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.
Practical
Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Readings

ENT 612  ADVANCED INTEGRATED PEST MANAGEMENT  2+0  SEM - II
(Pre-requisite ENT 510)

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

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

Suggested Readings
Koul O & Cuperus GW. 2007. Ecologically Based Integrated Pest Management. CABI.

ENT 613/ PLANT BIOSECURITY AND BIOSAFETY  2+0  SEM - I
(To be taught jointly by Entomology and Plant Pathology)

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

Theory
UNIT-I: History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

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


Suggested Readings
Biosecurity New Zealand. www.biosecurity.govt.nz
DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
ENTOMOLOGY

List of Journals

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

e-Resources

- http://www.colostate.edu/Depts/Entomology/
- http://www.ent.iastate.edu/list/
- http://www.biologybrowser.org/
- http://entomology.si.edu/
- http://www.intute.ac.uk/healthandlifesciences/agriculture/
- http://www.gbif.org/
- http://www.mosquito.org/
- http://www.nysaes.cornell.edu/fst/faculty/acree/pheronet/index.html
- http://www.ent.iastate.edu/list/
Suggested Broad Topics for Master’s and Doctoral Research

- Strengthening of eco-friendly strategies of integrated insect and mite pest management including:
  - Biological control
  - Bio-rational pesticides
  - Host plant resistance
  - Transgenic crop protection
  - Judicious use of pesticides
  - Molecular biosystematics

- Investigations on ecological factors including:
  - Survey and surveillance of insect and mite pests
  - Forecasting of insect and mite pest population life-tables and predictive models
  - Insect and mite biology
  - Population dynamics as influenced by abiotic and biotic factors

- Studies on role of pollination including honeybees in increasing crop yields and production of honey and other allied products and management of honeybee diseases and mites

- Pesticide resistance and Insecticide Resistance Management strategies

- Biotypes of pests

- Below ground biodiversity- Bio-indicator of soil health, role in decomposition of litter, soil physico-chemical properties

- Bioprospecting for protocols, peptides, genes, insecticidal proteins and antibiotics

- Climate change and pests

- IPM in protected cultivation

- Location specific IPM strategies in different cropping systems

- Genetic improvement of natural enemies

- Genetic improvement of silkworms

- Refinement of silkworm rearing technology for different regions

- Management of silkworm pests and diseases

- Crop-pest modeling

- Insect biochemistry- pheromones, hormones and neuropeptides

- Insect physiology- metabolism and regulatory mechanisms.

- Indigenous technology

- Plants as sources of insecticides

- Molecular systematics – finger printing of species

- Insect systematics and phylogeny
# Extension Education & Communication Management

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* Compulsory for Master’s programme; ** Compulsory for Doctoral programme

The following courses are recommended for M. Sc. / Ph. D. programmes from supporting subjects

### M. Sc.
- STAT 511  | Statistical Methods for Applied Sciences                                   | 3+1     |
- COMP 502  | Computer Fundamentals                                                      | 2+1     |

### Ph. D.
- STAT 513  | Sampling Techniques                                                        | 2+1     |
- COMP 501  | Computer Programming in Statistical Research                              | 2+1     |
EXTENSION EDUCATION & COMMUNICATION MANAGEMENT

Course Contents

EXT 501 DEVENTPMENT PERSPECTIVES OF EXTENSION EDUCATION 1+1 SEM - I

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

Theory
UNIT-I: Extension Education — Meaning, objectives, concepts, principles and philosophy, critical analysis of definitions — Extension Education as a Profession — Adult Education and Distance Education.
UNIT-II: Pioneering Extension efforts and their implications in Indian Agricultural Extension — Analysis of Extension systems of ICAR and SAU — State Departments Extension system and NGOs — Role of Extension in Agricultural University.
UNIT-IV: Current Approaches in Extension: Decentralised Decision Making, Bottom up Planning, Farming System Approach, Farming Situation Based Extension, Market Led Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

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

Suggested Readings
Van Den Ban AW & Hawkins HS. 1998. Agricultural Extension. 2nd Ed. CBS.

EXT 502 DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT 2+1 SEM - I

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

Theory
UNIT-I: Communication process — concept, elements and their characteristics — Models and theories of communication — Communication skills — fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication — Barriers in communication, Message — Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message.
UNIT-II: Methods of communication — Meaning and functions, classification. Forms of communication — Oral and written communication, Non-verbal communication,
interpersonal communication, organizational communication. Key communicators in
meaning, characteristics and their role in development.

UNIT-II: Media in communication Role of mass media in dissemination of
farm technology. Effect of media mix for Rural People. Modern communication media
Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer
Technology and its implications.

UNIT-IV: Agricultural Journalism as a means of mass communication, Its form and role
in rural development, Basics of writing News stories, feature articles, magazine articles,
farm bulletins and folders. Techniques of collection of materials for news stories and
feature articles; Rewriting Art of clear writing, Readability and comprehension testing
procedures; photo journalism, communicating with pictures, Radio and TV Journalism,
Techniques of writing scripts for Radio and TV.

Practical
Basics of writing stories, feature articles, popular and scientific articles, farm bulletins and
folders. Readability and comprehension testing procedures. Radio and TV journalisms
script writing, layout, design and editing. Communication drills to improve oral
communication skills.

Suggested Readings
Dahama OP & Bhatnagar OP. 2005. 
Education and Communication for Development. Oxford & IBH.
Farm Journalism. Agrotech Publ. Academy.
Ray GL. 2006. 
Extension Communication and Management. Kalyani Publ.
Rayudu CS.2002. 
Extension Education. Sree Lakshmi Press, Bapatla.

EXT 503  DIFFUSION AND ADOPTION OF INNOVATIONS  2+1  SEM - I

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

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

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

**Suggested Readings**


**EXT 504**  
**RESEARCH METHODS IN BEHAVIOURAL SCIENCES**  
**2+1**  
**SEM - II**

**Objective**

This course is designed with a view to provide knowledge and skills in methods of behavioural sciences research and student will learn the Statistical Package for Social Sciences (SPSS) for choosing appropriate statistics for data analysis.

**Theory**


UNIT-II: Objectives Í Meaning, types and criteria for judging the objectives. Concept and Construct Í Meaning, role of concepts in research and Conceptual frame work development in research. Variable Í Meaning, types and their role in research. Definition Í Meaning, characteristics of workable definitions, types and their role in research. Hypothesis Í Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement Í Meaning, postulates and levels of measurement, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity Í Meaning and methods of testing. Reliability Í Meaning and methods of testing. Sampling Í Universe, Sample and Sampling- Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors Í Methods of elimination and minimizing, Maximincon Principle, Sampling Í Types of sampling and sampling procedures.

UNIT-III: Research Designs Í Meaning, purpose and criteria for research design. Types, advantages and limitations of each design. Experimental design Í Advantages and limitations. Data Collection devices - Interview Í Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules Í Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires Í Meaning, difference between schedule and questionnaire, types of questions to be used, pre Í testing of the questionnaires or schedules and advantages and limitations. Check lists Í Meaning, steps in construction, advantages and limitations in its use. Rating scales Í Meaning, types, limits in construction, advantages and limitations in its use. Observation Í Meaning, types, tips in observation, advantages and limitations in its use. Case studies Í Meaning, types, steps in conducting, advantages and limitations in its use. Social survey Í Meaning, objectives, types and steps in conducting, advantages and limitations.

UNIT-IV: Data processing Í Meaning, coding, preparation of master code sheet, analysis and tabulation of data, Statistical Package for Social Sciences (SPSS), choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing Í Meaning, guidelines to be followed in scientific report writing. References in reporting.
Practical
Selection and formulation of research problem - Formulation of objectives and hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-Development of data collection devices.-Testing the validity and reliability of the data collection instruments.-Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, hands on experiences on SPSS, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research. Writing report, Writing of thesis and research articles-Presentation of reports.

Suggested Readings

EXT 505  E- EXTENSION  2+1  SEM - II
Objective
Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. Reaching the unreached.

Theory
UNIT-I: ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities.
UNIT-II: ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc.

Practical

Suggested Readings
ENTREPRENEURSHIP DEVELOPMENT 2+1 SEM - II AND MANAGEMENT IN EXTENSION

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

Theory
UNIT-II: Micro enterprises  Profitable Agri enterprises in India  Agro Processing, KVIC industries. Micro financing  meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises  Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development  Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises  Issues relating to success and failure of enterprises  Personal, Production, Finance, Social, Marketing.

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

Suggested Readings

159
EXT 507  HUMAN RESOURCE DEVELOPMENT  2+1  SEM - I

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

Theory
UNIT-I: Human Resource Development ï Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; HRD Interventions ï Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment ; Motivation productivity - job description ï analysis and evaluation; Performance Appraisal.

UNIT-II: Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception ; Stress and coping mechanisms; Inter-Personal Process, Helping Process ï communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building ï Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager ï Responsibility of Professional Manager; Managerial skills and Soft Stills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics :Leadership styles ï Group dynamics.

UNIT-III: Training ï Meaning, determining training need and development strategies ï Training types, models, methods and evaluation; Facilities for training ï Trainers training ï techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate ï organizing for HRD ï emerging trends and Prospective.

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

Suggested Readings
EXT 508  VISUAL COMMUNICATION  2+1  SEM - I

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

Theory
UNIT-II: Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and production of low cost visuals.
UNIT-IV: Pre-testing and evaluation of visuals. Scanning of visuals.

Practical

Suggested Readings

EXT 509  PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER  1+1  SEM - II

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

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

Suggested Readings

EXT 510  GENDER SENSITIZATION FOR DEVELOPMENT  1+1  SEM - II

Objective
In this course the students will learn about an overview of the concept of gender and gender balance on development and develop skills of identifying gender roles, rights, responsibilities and relationships on development. Besides the students will also learn the attitudinal change to internalize gender equity concerns as fundamental human rights and also enhance the capability for identifying and analyzing gender issues in agriculture and allied sectors.

Theory
UNIT-I: Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques.
UNIT-II: National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors I need and relevance; Gender budgeting I A tool for empowering women.
UNIT-III: Women empowerment I Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights ; Action plans for gender mainstreaming.

Practical
Visits to rural institutions of women for studying in the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for women development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

Suggested Readings
Sahoo RK & Tripathy SN. 2006. SHG and Women Empowerment. Anmol Publ.

EXT 511  PERSPECTIVES OF DISTANCE EDUCATION  1+1  SEM - II

Objective
The course is intended to orient the students with the concept of Distance Education, Characteristics of Distance Education, Evolution, Methods of Distance Education, Different Approaches in Planning Distance Education, Educational Technology in Distance Education, Management of Resources for distance education, Strategies for maximizing the reach and programme evaluation and quality assessment.

Theory
UNIT-I: Distance Education I Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education I Evolution and Historical view of Distance Education I Theory Methodology, and Epistemology. Dimensions of Distance Education,
Scope and difficulties. Open Education î Non-formal Education, Continuing Education, Education by correspondence.

UNIT-I: Forms and systems of Distance and Open Education, Modes of Teaching and Learning in Distance Education, Methods of Distance Education, Significance of Distance Education in Teacher Education.

UNIT-II: Planning Distance Education î A Systems Approach Student Learning î Course Planning. The target groups î Barriers to learning in Distance Education î Planning and Management of Networked Learning.

UNIT-IV: Educational Technology is Distance Education Application of information and Educational Technologies in Distance Education, Development of Course and Course material, Management of resources, processes, Forms of Instructional material in Distance Education and Media Development and Production in Distance Education - Video Classroom Strategy in Distance Education î Strategies for maximizing the reach î services to students, programme Evaluation - performance indicators and Quality Assessment.

Practical
Visit to the University which is implementing the Distance Education Programmes. Detailed Study of their programme in relation to Educational Technology, Methodology, Curriculum Development, Evaluation and Assessment. Exercise on development of curriculum for Distance Education exclusively for farming community.

Suggested Readings
Holmberg B. 1995. Theory and Practice of Distance Education. Routledge Publ.
Sharma DC. 2005. Management of Distance Education. Anmol Publ.

EXT 601 ADVANCES IN AGRICULTURAL EXTENSION 2+1 SEM - I

Objectives
By the end of the course student will be able to:-
• Critically analyze different Agricultural Extension approaches
• Understand Agricultural Knowledge Information System (AKISs) ITK
• Understand Advances in Extension - Cyber extension, ICT enabled extension services; Market Led Extension, Public Private Partnership, Mainstreaming gender in extension organizational Innovations.
• Visualize implications of WTO - AOA and develop extension strategies.
• Understand extension reforms and Farmer Field Schools Decentralized Decision Making, bottom up planning, ATMA, FSBE & CIGs etc., ATIC, IVLP & Kisan Call Centres

Theory
UNIT-I: Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.


UNIT-III: Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension.

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.

Suggested Readings

EXT 602 ADVANCED DESIGNS AND TECHNIQUES 2+1 SEM - I
IN SOCIAL SCIENCE RESEARCH

Objective
By the End of the course student will be able to:-
- Develop & Standardize Attitude scale using different techniques of attitude scale construction.
- Develop skills of using Projected & Semi Projected & Semi Projected Techniques, Computer Package analysis and PRO Tools in Extension Research.

Theory
UNIT-I: Scaling technique - meaning, types, principles, steps and quality, techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive Intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Reliability and Validity of Scales. Sociometrics, content analysis, case studies, Q-sort techniques, Semantic different technique.

Practical
Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques. Content analysis, case studies. Practicing participatory tools and techniques. Hands on experience on Computer Preparation and Data Collection instruments, review of previous studies.

Suggested Readings
EXT 603  ADVANCES IN TRAINING TECHNOLOGY  2+1  SEM - II

Objectives

By the end of the course student will be able to:

- Plan and design a training programme
- Plan & Develop effective training sessions
- Manage difficult situations while organizing training programmes
- Use different advanced participatory training methods

Theory

UNIT-I: Paradigm shift in training - learning scenario, Training Approaches - Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, Course Objective, content and methods.

UNIT-II: Designing an effective training session - the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees).

UNIT-III: Recent Training Techniques for understanding and facilitation team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training, Psychological instruments as training tools: TAT, Inventories, Cases, etc.


Practical


Suggested Readings


EXT 604  ORGANIZATIONAL DEVELOPMENT  2+1  SEM - II

Objective

By the end of the course student will be able to Understand & Study the Organization in terms of types, Characteristics, Needs, Motives, Organization behaviour, Organization Communication, Organization development and Individual behaviour in organization. To analyse the factors effecting organizational effectiveness and distinguish between functional and non functional organization.

Theory

UNIT-I: Introduction to organizations: Concept and Characteristics of organizations, Organizational Behaviour - Context and concept - levels of organizations - formal and
informal organizations, Theories of organizations: Nature of organizational theory - classical theories - features of Bureaucracy - administrative theory and Scientific management - Neo-classical theories - the human relations movement - modern theory.

UNIT-II: Systems approach to study organization needs and motives - Attitude, values and ethical behaviour - alienation and work - work motivation - communication and interpersonal behaviour - organization communication - leadership behaviour - decision making, problem solving techniques - organizational climate - change proneness and resistance to change. Organizational change. Organizational structure - Process in organizing - Dimension of Motivation Climate.


Practical

Suggested Readings

**EXT 605 ADVANCED INSTRUCTIONAL TECHNOLOGY 2+1 SEM-1**

**Objectives**
By the end of the course student will be able to:-
- Understand Agricultural Education Scenario in the country and Curriculum development process
- Plan & Prepare and present course outline, Lesson Plan & Skill plan
- Develop appropriate Teaching & Learning Styles
- Use innovative instructional aids & methods

**Theory**
E-Learning, Art of Effective Communication, Distance education, Student evaluation - Question Bank, Appraisal of Teacher Performance, Review of research in Instructional Technology.

**Practical**

**Suggested Readings**

**EXT 606**
**COMPARATIVE EXTENSION**

**Objective**
By the end of the course student will be able to understand the different extension programmes/approaches and systems of the developed and underdeveloped countries.

**Theory**
UNIT-I: Genesis of extension programmes: development of extension work in USA and implications of the legislative measures; extension work in UK, China, Netherlands and Afro-Asian countries.
UNIT-II: Efforts made for social welfare in the past and progress of the NES and Community Development Programme in India.
UNIT-III: Distinguishing characteristics of the Indian extension system with that of the USA, Netherlands, Japan, Pakistan, Taiwan, Australia and Denmark; Critical appreciation of the Community Development Programme of India

**Suggested Readings**

**EXT 607**
**ADVERTISING AND MARKETING**

**Objective**
To help the students to know the concept, evaluation, history, classification, various media for advertising, socio-economic effects of advertising, trends in advertising and marketing, govt. policy on advertising and marketing and to develop competency in creating advertisements for mass communication.

**Theory**
UNIT-I: Evaluation and history of advertising, relevance of advertising in marketing, an overview of the advertising scene in India.
UNIT-II: Classification of advertising; various media for advertising, advertising writing process; law and ethics in advertising, socio-economic effects of advertising.
UNIT-III: Advertising agency, operations/management, an understanding of key issues, strategies in advertising govt policy on advertising and management, apex bodies in advertising.

UNIT-IV: Advertising as a tool of marketing and Advertising campaigns and their role in marketing. Marketing communication - concept and functions, consumer behaviour and its various factors; recent trends in advertising and marketing.

Practical
Visit to advertising agencies, advertising layout techniques for newspaper, radio, posters, TV, hoardings, wall paintings, case studies on institutional advertisement, advertisement campaign.

References
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 Ī 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 Ī different types of intro and leads. Exercise of Writing for Radio, TV. Preparation of story board for farm Video Production Ī 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.

Suggested Readings

EXT 609 TRANSFER OF TECHNOLOGY IN AGRICULTURE 2+1 SEM - II

Objectives
By the end of the Course student will be able to:-
• Develop thorough understanding on different systems of Technology Transfer
• Develop appropriate communication & Media Strategy suitable to the System of Technology Transfer
• Analyse the constraints in Systems of Technology Transfer Technology and Suggest suitable Strategies.

Theory
UNIT-II: Appropriateness of communication media in the system of technology transfer. New communication strategy for transfer and adoption of Agricultural technology. Extension training in transfer of technology.
UNIT-III: Analysis. Constraints in Transfer of Technology, agencies or departments involved in TOT. Extension professional in TOT. Attributes of Technology and its Relation in TOT process. TOT to resource poor farmers. Role of Key communicators or local leaders in TOT. Private and Public partnership in TOT.

Practical
Analysis of Transferred technology. Analysis of knowledge generation and consuming systems. Formulation of communication strategies. Study of attributes of selected fast spreading technologies and slow technologies, study of constraints in TOT, visit to TOT 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.

Suggested Readings
List of Journals

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

E-Resources

- www.pearsoned.com (Pearson Education Publication)
- www.oup.com (Oxford University Press)
- www.emeraldinsight.com (Emerald Group Publishing)
- www.sagepub.com (Sage publications)
- www.macmillanindia.com (Macmillan Publishing)
- www.krishworld.com (Agriculture Portal)
- www.aiaee.org (The Association for International Agricultural and Extension Education)
- www.geogate.org (Agriculture Portal)
- www.icar.org.in (Indian Council of Agricultural Research)
- www.manage.gov.in (National Institute of Agricultural Extension Management)

Suggested Broad Topics for Master’s and Doctoral Research

- Agricultural communication
- Agricultural Journalism
- Agriculture Education
- Agro Forestry Extension
- Banking & Credit
- Commercialization and Diversification in Agriculture
- Vegetables
- Horticulture
- Agri. tourism
- Floriculture
- Mushroom cultivation
- Bee Keeping
- Organic Farming
  - Cropping System/Farming System
  - Diffusion and Adoption
  - Dry Farming Technology
  - Entrepreneurship Development
  - Extension Administration and Management
  - Extension Methods and techniques
  - Extension Trainings
  - Extension Management and Sustainable Agricultural Development
  - Indigenous Practices
  - Rural Organization and Institutions
  - Scientific Productivity and Human Resource Development
  - Youth/Women Development
  - Social Marketing
## Forestry

### Course Structure

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### Compulsory Non-Credit Deficiency Courses (For non-Forestry Graduates)

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### Supporting courses for M. Sc.

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### Supporting courses for Ph. D.

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### Service Course

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* Compulsory for M.Sc. Programme; **Compulsory for Doctoral Programme.
FORESTRY

Course Contents

FOR 501  SILVICULTURE  2+0  SEM - II

Objective
To provide knowledge about Forest ecosystem concept, stand dynamics, forest succession, productivity and vegetation forms and natural regeneration of tree species.

Theory
UNIT-I: Forest ecosystem concept, stand dynamics-forest succession, competition and tolerance, classification of world's forest vegetation.
UNIT-II: Productivity and vegetation forms of India, forest composition and structure. Ecophysiology of tree growth, effect of radiation & water relationship, mineral nutrients and temperature.
UNIT-III: Natural regeneration of species and types including unevenaged silviculture. Intermediate treatments.

Suggested Readings

FOR 502  FOREST BIOMETRY  1+1  SEM - II

Objective
To develop understanding of students about tree measurements, forest inventory and yield concepts

Theory
UNIT-II: Forest inventory, Sampling methods adopted in forestry, Use of GPS in forest inventory. Measurement stand density. Simulation techniques.
UNIT-III: Growth and yield prediction models in their preparation and applications.

Practical
Calculations of volume of felled as well as standing trees., Volume table preparation., Application of sampling procedures., Handling of GPS., preparation of yield and stand table.

Suggested Readings

FOR 503  FOREST MANAGEMENT  2+0  SEM - I

Objective
To provide knowledge about forest management, ecosystem management, site quality evaluation, stand density & forest valuation.

Theory
UNIT-I: Principles of forest management; scope and object of forest management, ecosystem management, development of forest management in India.
UNIT-II: Site quality evaluation and importance. Stand density, classical approaches to yield regulation in forest management, salient features and strategies.

Suggested Readings
FOR 504  FOR 505

FOREST PRODUCTS – CHEMISTRY AND INDUSTRIES  FOREST ECOLOGY AND BIODIVERSITY

1+1  2+1  SEM - II  SEM - I

Objective
The course will equip the students regarding wood based industries. How it is affecting the economy of the country such as match and splint, sports and pencil making, besides this wood extracts resins and gums, katha, tannis and various type of non timber products. Practical will make them aware regarding extracting method of different products of wood.

Theory

UNIT-I: Importance of forest based industries in relation to Indian economy. Chemistry in relation to forest products.
UNIT-II: Description of different forest based industries - paper and pulp, furniture, bamboo, sports goods, pencil making, match box and splint making, use of wood of lesser known forest species for commercial purposes.
UNIT-IV: Chemical composition of oleoresin from major pine species. Structural difference among different gums (arabic, ghetti, tragacanth).
UNIT-V: Chemical nature and uses of volatile oils, tannins, katha and cutch. Chemical nature and uses of important forest based dyes and pigments.

Practical
Estimation of cell wall contents i Hemicellulose and lignin, Extraction of essential oils, resins, tannins, Acetylation of wood, Visit to nearby forest based industries.

Suggested Readings
Anonymous. 1981. Wealth of India. CSIR.
Anonymous. 2007. Year Book of Forest Products. FAO.
Krishnamurthy T. Minor Forest Products of India. Oxford & IBH.

FOR 505  FOR 504

FOREST ECOLOGY AND BIODIVERSITY  FOREST PRODUCTS – CHEMISTRY AND INDUSTRIES

2+1  1+1  SEM - I  SEM - II

Objective
To develop understanding of students about ecological aspects of forest, conservation of forest resources & biodiversity, consequences of depleting biodiversity and sustainable use of biodiversity.

Theory

UNIT-I: Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; Hierarchy issues in ecology.

Practical
Study of forest community structure and its successional status, Estimation of productivity of forest ecosystem, Trip to different regions of the state to study forest vegetation, Collection and preservation of specimen, Methods of vegetation analysis, Measurement of biomass and productivity, Quantification of litter production and decomposition, Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta.

Suggested Readings
FOR 506  AGROFORESTRY SYSTEMS  1+1  SEM - II

Objective
To impart knowledge on the concept of agroforestry land use including diagnosis and design methodologies.

Theory
UNIT-I: Agroforestry objectives, importance, potential and impediments in implementation. Land capability classification and land evaluation.
UNIT-II: Overview of global agro-forestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, shelter-belts and windbreaks, energy plantations and homestead gardens. Production potential of different silvi-pasture system.
UNIT-III: Concepts of community forestry and social forestry, linear strip plantations.
UNIT-IV: Diagnosis and Design i Trends in Agroforestry systems research and development.

Practical
Survey and analysis of land use systems in the adjoining areas. Design and plan of suitable models for improvement.

Suggested Readings
Ong CK & Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF.

FOR 507  FOREST PROTECTION  1+1  SEM - II

Objective
To provide knowledge to students about forest protection through diseases and pest management.

Theory
UNIT-I: Important diseases and insect pests of nurseries, farm forestry, plantations, avenue trees and their management. Assessment of losses due to diseases, insect pests, vertebrate pests, adverse weather, forest fires and weeds. Insect pests and mycoflora of seeds of forest trees and their management.
UNIT-II: Biodegradation of wood i microscopic and chemical effects of white rot, brown rot, soft rot and wood discoloration. Heart rots i factors affecting heart rots, damage caused, compartmentalization of decay in trees and management of heart rots. Role of mycorrhiza in tree health.
UNIT-IV: Biological control of insect pests and diseases of forest trees. Molecular tools for developing disease resistant trees.

Practical
Collection, identification and preservation of important insect pests and disease specimens of forest plants. Detection of insect infestation and seed borne mycoflora. Assessment of losses due to diseases, insect pests etc. Habitat management of vertebrate pests. Laboratory tests for estimating decay resistance in wood. Fire control methods and devices. Familiarization with the meteorological and plant protection equipment, Application of pesticides and bio-control agents in the management of insect pests, weeds,
diseases in nurseries and plantations. Extraction of spores of arbuscular mycorrhizal (AM) fungi from soil and assessment of mycorrhizal root infection.

Suggested Readings

FOR 508 TREE IMPROVEMENT 1+1 SEM - II

Objective
To acquaint the students about general principles of tree breeding with examples of important trees.

Theory
UNIT-I: General concept of forest tree breeding, tree improvement and forest genetics.
UNIT-IV: Seed, seed formation, dispersal, storage, stratification and seed dormancy.
UNIT-V: Selective breeding methods mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees. Indirect selection for biotic and abiotic stresses.
UNIT-VI: Progeny and clone testing. Seed orchards type, functions and importance. Estimating genetic parameters and genetic gain.
UNIT-IX: Biotechnology in tree improvement. Mutation breeding.
UNIT-X: Economics of tree breeding.

Practical

Suggested Readings
Mandal AK & Gibson GL. (Eds). 1997. *Forest Genetics and Tree Breeding*. CBS.

FOR 509 PLANTATION FORESTRY 2+1 SEM - II

Objective
To acquaint with various aspects of production, integrated nutrient and irrigation management and ecological factors in raising forest plantations.

Theory
UNIT-I: Role of plantation forestry in meeting the wood demand Plantation forestry in India and abroad, Purpose of plantation, Factors determining scale and rate of plantation, Land suitability and choice of plantation species
UNIT-II: Production technology for quality planting stock, preliminary site preparation for establishing plantation, Planting programme, time of planting, planting pattern, spacing, planting method.
UNIT-III: Nutritional dynamics and irrigation of plantation, Mechanization in plantation, Protection and after care of plantation, Pruning and thinning of plantation for quality wood
production, Rotation in plantation, Failure of plantations, Impact of interaction and integration of plantation forestry, Protective Afforestation, afforestation of inhospitable sites, Ecological factors and long term productivity, Sustainable yield from plantation.

UNIT-IV: Case studies in plantations of Eucalyptus, Sissoo, Poplars, Acacias, Prosopis cineraria, Ailanthus, A. indica, Teak, Melia sp., Bamboo, etc.

UNIT-V: Wasteland plantation

UNIT-VI: Industrial Plantation

Practical

Suggested Readings

FOR 510 ECONOMICS OF AGROFORESTRY SYSTEMS 2+1 SEM - II

(To be taught jointly by Agricultural Economics and Forestry)

Objective
To acquaint the students with principles of economics and use of economic tools in appraisal of the agroforestry systems.

Theory
UNIT-I: Basic principles of economics applied to agro-forestry. Optimization techniques. Planting, budgeting and functional analysis. Role of time, risk and uncertainty in decision making.

UNIT-II: Financial and socio-economic analysis of agro-forestry projects.

UNIT-III: Principles of financial management and harvesting, post harvest handling marketing of agro-forestry products including benefit sharing.

Practical
Exercises on agro-forestry production relationships. Preparation of enterprise, partial and complete budgets. Application of various methods in formulation and appraisal of agro-forestry projects. Case studies on harvesting, post harvest management and marketing of agro-forestry products.

Suggested Readings

FOR 511 BREEDING METHODS IN FOREST TREES 2+1 SEM - I

Objective
To acquaint the students about the concepts of sub-selection, population structure for breeding and production, genetic testing and making designs.
Theory
UNIT-I: Genetic constitution of tree populations, half-sib, full-sib family in trees. Hardy-Weinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes.
UNIT-II: Long-term and short-term breeding populations. Selective breeding methods-mass, family, within family, family plus within family. Grading system of plus trees in natural stands and plantations regression systems, mother tree selection, subjective evaluation. Selection for different traits.
UNIT-III: Genetic testing programmes - mating designs, complete designs - nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs - open pollinated mating and polycross mating. Experimental designs in genetic testing. Selection for disease resistance, tolerance to herbicide, salt, metals, high and low temperature, water stress. Marker assisted selection.
UNIT-IV: Breeding methods for wood quality, agroforestry, diseases and pest resistance, drought and salt resistance.
UNIT-V: Tree improvement case histories. Calculating gene and genotype frequencies. Flow chart for different breeding methods.

Practical
Half-sib, full-sib family in trees. Grading system of plus trees in natural stands. Mating designs, complete designs - nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs - open pollinated mating and polycross mating. Selection for biotic and abiotic stresses.

Suggested Readings
Mandal AK & Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.

FOR 601 QUANTITATIVE SILVICULTURE 2+1 SEM - II
Objective
To assess growth functions, dynamics of even aged and uneven aged forest. Thinning and growth, self thinning rule or 3/2 power law of self thinning.

Theory
UNIT-I: Growth functions-empirical, exponential, allometry and Backman’s growth function. Growth pattern and growth increment curve. Growth cycle and phases.
UNIT-II: Correlation between size and plant population. Probability of individual tree mortality. Models of mortality and yield for unthinned forest stands.

Practical
Growth characteristics and effect of temperature, nutrients and water stress on growth behaviour of nursery plants. Preparation of growth and increment curves.

Suggested Readings
FOR 602

ADVANCES IN TREE IMPROVEMENT

2+1

SEM - II

Objective

To develop understanding of students in application of mendelian, principles to forest trees and integration of physiological and molecular techniques for tree improvement programmes.

Theory

UNIT-I: Mendelican concepts as applied to forest trees. Cytological and chromosomal systems of forest trees. Cytoplasmic inheritance in trees. Colchiploid and mutation breeding for forest trees.

UNIT-II: Physiological basis of tree improvement. Pollution responses of trees. Pollen handling and hybridization techniques in forest trees. Tissue culture of trees.

UNIT-III: Molecular genetics as applied to forest trees, recent trends in tree improvement, somatic hybrids, transformation, gene sequencing. Inheritance of monoterpane composition in conifers.

UNIT-IV: Indirect selection for improvement of desired traits, molecular markers. Juvenile traits and their role in genetic evaluation in tree improvement programmes.


Practical

Cytology of pine root tips, kryotypic analysis, mutagenic treatments with colchicine and MH, tissue culture of organs, and transformation experiments, resin tapping and observation of trees for monoecium and dioecium.

Suggested Readings

Faulkner R. 1975. Seed Orchard Forestry, Commission Bull. No.34.

Mandal AK & Gibson GL. (Eds.). 1997. Forest Genetics and TreeBreeding. CBS.


FOR 603

ADVANCES IN WOOD AND NON-WOOD

3+0

SEM - I

FOREST PRODUCTS

Objective

To acquaint the students regarding updated and advance technology of timber mechanics, wood derivatives, import and export potential of non timber forest produce and latest computer application in forest produces.

Theory

UNIT-I: Mechanics of wood and wood composites, Application of orthotropic and non-linear constitutive relations, Laminate theory and failure criterion in the prediction of mechanical properties of solid woods; Wood-polymer, Hybrid composite processing.


UNIT-III: Methods of extraction, chemistry, processing, import and export potential of gums, resins, tannins, dyes, essential oils, fixed oils, cutch and katha, drugs, spices, poisons, insecticides, pesticides, wild edible fruits etc.

UNIT-IV: Computer application system in forest products, Use of information technologies to integrate material, quality and market fluctuations.

Suggested Readings

Anonymous. 1981. Wealth of India. CSIR.
Anonymous. 2007. Year Book of Forest Products. FAO.
Krishnamurthy T. Minor Forest Products of India. Oxford & IBH.
FOR 604 AGROFORESTRY SYSTEMS AND MANAGEMENT 1+1 SEM - II

Objective
To impart knowledge on recent development on agroforestry models and its economics.

Theory
UNIT-I: Rationale for research proposals: live fences, boundary plantings, hedgerow intercropping, mixed intercropping, fodder banks, woodlots; Possible experimental designs.
UNIT-II: The use of economics in diagnosis and design of Agroforestry systems; Costs and benefits in Agroforestry; Valuation of inputs and outputs; Environmental outputs
UNIT-III: Discounting rates for private and public economic analysis; Discounted measures of economic worth; Non-numerical economic analysis; Methodology for the exploration and assessment of multipurpose trees
UNIT-IV: 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; Modelling in Agroforestry; Elements.

Practical
Developing formats for diagnosis and design investigations; Discussion on published cases of discounting in Agroforestry; Valuation of input and output; Case study on B C ratios for community forestry; Scoring for multiple use of different species; Listing a hundred species of tropical origin; Market trends in tree based products; Study of impact of agroforestry/social forestry on wildlife; Birds and small animals; General of ergonomic data from Agroforestry practitioners in farmlands; Farmers responses to Agroforestry/community forestry; Studies on light and shade effects of trees on understorey plants. A review; The role of voluntary agencies/industries in promoting afforestation programmes; The impact of training to farmers, agricultural officers and others in promoting Agroforestry; Experience of Birsa Agricultural University. Constraints in adoption of Agroforestry; Farmers view point; Visit to agave & biofuel plantations and report on its management practices; Industry; Farmer nexus; Wasteland development; Fuel wood plantations, Biomass productivity assessment; Develop models for rehabilitation of saline and alkaline areas.

Suggested Readings

FOR 605 FORESTRY INTERVENTIONS FOR ENVIRONMENT AMELIORATION 1+1 SEM - I

Objective
To develop understanding of students about environmental sustainability and forestry interventions for environment amelioration

Theory
UNIT-I: Environmental amelioration ñ concept and challenges. Integration of environmental conservation strategies and economic development.
UNIT-II: Forestry interventions viz. Plantation forestry, industrial forestry, urban forestry, fuelwood/energy forestry including biofuels, short rotation forestry, Agroforestry, biodiversity parks, Sanctuaries and national parks and catchment plantations.
UNIT-IV: Environmental concerns, monitoring methods, health & safety, environmental training, environmental organization.

Practical
Study structure an functions of forestry interventions. Analysis of the micro-environmental attributes viz. temperature, humidity, solar radiations, soil erosion, in-situ measurement of sediment load in native water bodies, native fauna and flora, measurement of particulate air pollutants and other gases.

Suggested Readings

FOR 606 ADVANCES IN SILVICULTURE 1+1 SEM - II

Objective
To develop understanding of students about advance in Silviculture and silvicultural practice. Effect of silvicultural practices on forest stand management and stand development. Advances in coppice silviculture.

Theory
UNIT-I: Philosophy of silviculture ï Advance reproduction methods and their role in silviculture ï Judging successful establishment; Analysis of active and passive site preparation ï Silviculture with an ecosystem approach
UNIT-II: Advance silvicultural practices in rain forest; Tropical forest; Subtropical forest, Temperate forest; Mechanization and role in Silviculture
UNIT-III: Analysis of different techniques of silviculture in forest stand management, Technique for early stand development; Analysis of thinning methods and its impact on wood yield and quality; Stand protection and health management
UNIT-IV: Advance silviculture techniques for plantation forestry; Case studies of advance silviculture in India and abroad; Advances in coppice Silviculture.
UNIT-V: Adjusting silviculture to meet industrial demands ï Silviculture in perspective ï Problem solving procedure for silviculture ï Silviculture in retrospect.

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

Suggested Readings
FOR 607 ADVANCES IN FOREST REPRODUCTIVE BIOLOGY 1+1 SEM - I

Objective
To develop understanding of students about phenology, phenodynamics breeding behaviour pollination biology and breeding systems in forest trees.

Theory
UNIT-II: Pollination, biology, pollination ecology of tropical and temperate forest tree species, plant-pollination interactions. Pollinator energetic and nectar production

Practical
Phenological studies in forest trees, nectar collection and analysis, pollination trapling distances, foraging behaviour, pollinator identification and visitation.

Suggested Readings
Mandal AK & Gibson GL.(Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.

FOR 608 ADVANCES IN AGROFORESTRY RESEARCH AND MANAGEMENT 2+0 SEM - I

Objective
To teach how to refine the Agroforestry systems’ management practices and their integration for developing suitable Agroforestry systems.

Theory
UNIT-I: Recent trends in Agroforestry research and development. Agroforestry land use systems and their salient features.
UNIT-II: Study of systems specification, prioritizing potential interventions and technology specifications; space and time related considerations.
UNIT-III: Introduction to on farm and on station research experiments. Factors affecting biomass production.
UNIT-IV: Soil-site sustainability and environmental resource sharing. Site-Species compatibility. Competition predation, mutualism, commensalisms. Simulation modeling of Agroforestry systems.

Suggested Readings
DEFICIENCY COURSES FOR NON FORESTRY GRADUATES

FOR 451 PRINCIPLE AND PRACTICES OF SILVICULTURE 2+0 SEM - I

Objective
To acquaint the students about general principles and practices of silviculture in India with examples of important trees.

Theory
UNIT-I: Definition of forest and forestry. Classification of forest and forestry, branches of forestry and their relationships. Definition, objectives and scope of Silviculture. Status of forests in India and their role. History of forestry development in India.
UNIT-II: Site factors - climatic, edaphic, physiographic, biotic and their interactions. Classification of climatic factors. Role played by light, temperature, rainfall, snow, wind, humidity and evapo-transpiration in relation to forest vegetation.

Suggested Readings

FOR 452 FOREST MENSURATION 1+1 SEM - I

Objective
To acquaint the students about measurements of growth, wood production, biomass production and forest inventory.

Theory
UNIT-I: Introduction, definition, objectives and scope of forest mensuration. Scales of measurement (nominal, ordinal, interval and ratio scale). Units of measurement, standards of accuracy implied in their expression.
UNIT-V: Tree growth measurements, objectives increment, determination of increment, stump analysis, stem analysis and increment boring. Measuring tree crops - objectives, diameter, diameter and girth classes, height measurement of crop, crop age and crop volume. Stand tables.
UNIT-VI: Forest inventory- definition, objectives, kinds of enumeration. Sampling - definition, advantages, kinds of sampling, random sampling: (simple, stratified, multistage and multiphase sampling). Non random sampling (selective, systematic and sequential sampling) sampling design, size and shape of the sampling units. Point sampling - horizontal and vertical point sampling. Introduction to remote sensing and its application in forestry.
Practical

Suggested Readings

FOR 453 PRINCIPLES OF TREE IMPROVEMENT 1+1 SEM - I

Objective
To acquaint the students about basic concepts and general principles of tree improvement.

Theory
UNIT-I: Introduction, history and development of tree improvement, its relation to other disciplines for forest management. Reproduction in forest trees – anthesis and pollination – their importance in tree breeding.
UNIT-III: Genetic basis of tree breeding and selection practices in forest trees. Patterns of environmental variation- species and provenance trials in forest trees. Seed stands (seed production areas) Plus tree selection, progeny trials and establishment of seed orchard.
UNIT-IV: Genetic consequences of hybridization. Back cross breeding, heterosis breeding, breeding for specific purposes.
UNIT-V: Conservation of forest tree germplasm. Recent techniques in tree improvement. Vegetative propagation and tree improvement.

Practical

Suggested Readings
Mandal AK & Gibson GL. (Eds.). 1997. *Forest Genetics and Tree Breeding*. CBS.

FOR 454 WOOD PRODUCTS AND UTILIZATION 1+1 SEM - I

Objective
To acquaint the students about various wood products, availability of raw material and best utilization practices in India.

Theory
UNIT-I: Pulp and paper industry. Introduction and raw material; pulping mechanical, chemical, semi-chemical and semi-mechanical; pulp bleaching; stock preparation and
sheet formation; types of paper; manufacture of rayon and other cellulose derived products.

UNIT-II: Manufacture, properties and uses of Composite wood- plywood, fiber board, particle board and hard board.


Practical

Suggested Readings
Anonymous. 2007. *Year Book of Forest Products*. FAO.

FOR 455  FOREST MANAGEMENT, POLICY AND LEGISLATION

Objective
To acquaint the students about general principles of forest management, working plan, forest policies and forest legislation in India.

Theory


UNIT-III: Yield regulation general principles of even aged and uneven aged forest crop. Yield regulation based on area, volume, area and volume, increment and number of trees.


Practical
Visit to plantations of different age gradations, record the actual growing stock and workout increments. Visit to forests and enumerate the stock and test one of the method for yield regulation. Study the various units adopted in the forest management. Study of various records and forms maintained in the office of the RFO with regard to management of forests under their control. Study of procedure for seizure of property. Visit to forest department and courts to observe penalty procedures. Preparation of first information report and enactment report. Study of working plans of the forests and to prepare the working plan for one of the area in the range.

Suggested Readings
FORESTRY

List of Journals

- *Forest Genetic Resources* (FAO).
- *Indian Forester* (ICFRE, Dehradun).
- *Journal of Tree Sciences* (Indian Society of Tree Scientists, Dr. Y. S. Parmar University of Horticulture and Forestry, P.O.: Nauni, Solan).
- *Myforest* (Karnataka Forest Department, Bangalore-560003).
- *Silvae Genetica* (Institute for Forest Genetics and Tree Breeding, Germany).
- *Unasyla* (FAO).
- *Wood Science and Technology* (Springer-Verlag).

e-Resources

- www.hau.ernet.in/ejournals.htm
- www.manage.gov.in/managelib/onlinejrnls.htm
- www.gbpuat.ac.in/acads/cfors/index.htm
- www.usbangalore.edu.in
- www.kuvempu.ac.in/libraryweb/lib-cjou.htm
- www.clickindia.com
- www.gbphed.nic.in/library/catalog.htm
- www.tnau.ac.in/lib/libej.html
- www.anves.lib.unn.edu/dalenv.phtml
- www.elibrary.icrisat.org/
- www.icfre.org
- www.ias.ac.in
- www.hmlibrary.ac.in
- www.yspuniversity.ac.in/library/library-int.htm
- www.du.ac.in/du/achievementsoftheyear07.pdf
- www.anndhrauniversity.info/inaugurationmessage.html
- www.elsevier.de/ufug.
- www.btisnet.nic.in/wordfiles/E-Journal.doc
- www.teriin.org/
- www.icar.org.in
- www.knowledgecommission.gov.in
- www.mail.iari.res.in/library
- www.lib.iastate.edu/collections/eresourc/eresourcag-for-toc.html
- www.wood-report.de
- www.geocities.com/utmfc/forestry_links.htm
- www.bfw.ac.at
- www.donnelly.nmh.edu/articles/databases.asp?subject=Forestry
- www.cabi.org

Suggested Broad Topics for Master’s and Doctoral Research

- Breeding for biotic and abiotic stresses in important tree species
- Domestication and breeding of unexploited tree/shrub species
- Epidemiology and management of tree diseases in nursery and plantations
• Etiology and management against tree decline/mortality
• Problems and management of insect-pests and nematodes in forest tree species
• Studies on biomass production, nutrient cycling and carbon sequestration in different agroforestry systems
• Studies on above and below ground interactions in different agroforestry systems
• Studies on phytoremediating potential of different tree species
• Identification of tree species for biodrainage in reclamation of waterlogged areas
• Use of conventional breeding, biotechnology and mutation breeding in development of fast growing and transgenic trees for short rotation agroforestry systems
• Genetic improvement and development of short statured, early bearing and high seed yielding genotypes in different tree borne oilseeds (TBOs)
• Agroforestry systems and their effects on sustainable productivity
# GENETICS AND PLANT BREEDING

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<td>GP 608**</td>
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*Compulsory for Master’s programme; ** Compulsory for Doctoral programme

1 2 3 4 To be taught by Genetics and Plant Breeding
GENETICS AND PLANT BREEDING

Course Structure

GP 501 PRINCIPLES OF GENETICS 2+1 SEM - I

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

Theory
UNIT-I: Beginning of genetics; Early concepts of Inheritance; Mendel's laws; Discussion on Mendel's paper; Chromosomal theory of inheritance; Multiple alleles; Gene interactions; Sex determination, differentiation and sex-linkage; Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes; Somatic cell genetics; Extra chromosomal inheritance; Male sterility and incompatibility.
UNIT-II: Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Recombination in bacteria, fungi, viruses; Tetrad analysis; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis; Genetic fine structure analysis; Allelic complementation, Split genes; Transposable genetic elements; Overlapping genes, Pseudogenes, Oncogenes; Gene families and clusters.
UNIT-III: Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression; Gene regulation in eukaryotes; RNA editing; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification; Gene isolation, synthesis and cloning; genomic and cDNA libraries; PCR based cloning, positional cloning; Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).
UNIT-IV: Genomics and proteomics; Functional and pharmacogenomics; Metagenomics; Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; Genetics of mitochondria and chloroplasts.
UNIT-V: Population- Mendelian population, random mating population; Frequencies of genes and genotypes- causes of change; Hardy-Weinberg equilibrium; Concepts of Eugenics, Epigenetics; Genetic disorders and Behavioural genetics; Overview of recent discoveries in the field of genetics.

Practical
Laboratory exercises on probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Pedigree analysis in humans, Problems on HWE, Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification -Electrophoresis Í basic principles and running of amplified DNA -Extraction of proteins and isozymes; Visit to experimental farm, glasshouse and learning some practical considerations.

Suggested Readings:

GP 502 PRINCIPLES OF PLANT BREEDING 2+1 SEM - I

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


UNIT-II: Genetic basis of breeding self-and cross-pollinated crops including mating systems and response to selection - nature of variability, components of variation, heritability and genetic advance, genotype-environment interaction, general and specific combining ability, types of gene actions and implications in plant breeding; plant introduction and role of plant genetic resources in plant breeding.

UNIT-III: Pure line theory; pure line selection and mass selection methods, line breeding, pedigree, bulk, backcross, single seed descent and multiline method; population breeding in self-pollinated crops (diallel selective mating approach).

UNIT-IV: Breeding methods in cross pollinated crops, population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites; hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT-V: Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

UNIT-VI: Self-incompatibility and male sterility in crop plants and their commercial exploitation; concept of plant ideotype and its role in crop improvement; transgressive breeding.

UNIT-VII: Special breeding techniques - Mutation breeding, Breeding for abiotic and biotic stresses.

UNIT-VIII: Cultivar development-testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical


Suggested Readings

Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

GP 503 PRINCIPLES OF CYTOGENETICS 2+1 SEM - II

Objective

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

Theory

UNIT-I: Architecture of chromosome in prokaryotes and eukaryotes; Chromomemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere - Artificial chromosome construction and its uses; Special types of chromosomes.

UNIT-II: Chromosomal theory of inheritance - Cell Cycle and cell division - mitosis and meiosis, Differences, significance and deviations - Synapsis, structure and function of
synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over mechanisms and theories of crossing over recombination models, cytological basis, Variation in chromosome structure; evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - in situ hybridization and various applications.

UNIT-II: Structural and Numerical variations of chromosomes and their implications - Symbols and terminologies for chromosome numbers - euploidy - haploids, diploids and polyploids; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras - endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes.

UNIT-IV: Inter-varietal chromosome substitutions, Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids - Role of aneuploids in basic and applied aspects of crop breeding; their maintenance and utilization in gene mapping and gene blocks transfer - Alien addition and substitution lines - creation and utilization; Apomixis: Evolutionary and genetics problems in crops with apomixis.

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

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

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; preparing specimen for observation - Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion and Aloe vera - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops - Various methods of staining and preparation of temporary and permanent slides - Pollen germination in vivo and in vitro - Microtomy and steps in microtomy. Agents employed for the induction of various ploidy levels; solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids: Anther culture and Ovule culture - Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly - Morphological observations on allopolyploids - Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation; Polyploidy in ornamental crops. - Fluorescent in situ hybridization (FISH)- Genome in situ hybridization GISH

Suggested Readings

GP 504  POPULATION GENETICS  2+1  SEM - I

Objective
To impart knowledge on structure, properties of equilibrium population, forces influencing gene and genotypic frequencies, breeding values of different population, average effects of gene substitution and correlation between relatives.

Theory
UNIT-I: Concepts of population, properties of population; Role of population genetics; Mendelian population: Genetic constitution of a population through time, space, age structure etc.; Probability rules in relation to Mendelian inheritance; Mating systems: Random mating population; Frequencies of genes and genotypes: causes of change (population size, differences in fertility and viability), migration and mutation; Natural, idealized and non-idealized population.
UNIT-II: Hardy-Weinberg Equilibrium: Proof and applications of the Hardy-Weinberg law; Hardy-Weinberg law: Single locus with two allele and multiple alleles; Sex linked genes; Forces affecting gene frequencies and equilibrium; Mean of random mating population: dominance, no-dominance and codominance cases; Wahlund's principle; Snyder's ratio; Gene substitution and average effects; Breeding value: effect of random mating in succeeding generations.
UNIT-III: Fisher's theorem of natural selection, Migration, Mutation, Recurrent and non recurrent selection; Balance between selection and mutation, Selection favouring heterozygotes, Over dominance for fitness; Genetic equilibrium for multiple loci; Linkage disequilibrium; Polygenes and continuous variation, components of variation; Covariances; Non- random mating, selfing, back crossing; Inbreeding coefficient, panmictic index, sib mating; Assortative mating and disassortative mating; Pedigree populations and close inbreeding.
UNIT-IV: Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Theory of path and regression in applied population genetics; Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis, adaptive organization of gene pools; Polymorphism, balanced and non-balanced polymorphism, heterozygous advantage; Survival of recessive and deleterious alleles in populations; Founders principle; Equilibrium in autopolyploidy; Generalized zygotic distribution and meiotic drive; Electrophoretic variants of proteins and molecular approach in the study of population.

Practical
Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium.

Suggested Readings

GP 505  PRINCIPLES OF QUANTITATIVE GENETICS  2+1  SEM - II

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

UNIT-I: Mendelian traits vs polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation - Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions - Nature of gene action - additive, dominance, epistatic and linkage effects

UNIT-II: Principles of Analysis of Variance (ANOVA) - Expected Variance Components, Random and fixed models, MANOVA, Biplot Analysis, Comparison of Means and variances for significance


UNIT-IV: Generation mean analysis, mating designs - Diallel, Partial Diallel, Line x tester analysis, NCDs and TTC., Concepts of combining ability and gene action - Analysis of genotype x environment interaction - adaptability and stability, Models for GxE analysis and stability parameters - AMMI analysis - principle and interpretation

UNIT-V: QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis, Marker Aided Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - Factors influencing MAS

Practical


Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping - statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different population and interpretation, Biparental mating, Triparental analysis, Quadruparental analysis and Triple Test Cross (TTC) - use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

MUTAGENESIS AND MUTATION BREEDING 2+1  SEM - I

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

Theory
UNIT-I: Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms - paramutations
UNIT-H: Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations viz., X rays, γ rays, α and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects - RBE and LET relationships
UNIT-II: Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects - Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: external and internal sources - oxygen, water content, temperature and nuclear volume
UNIT-IV: Chemical mutagens- Classification - base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action - Dose determination and factors influencing chemical mutagenesis - Treatment methods using physical and chemical mutagens - combination treatments; Other causes of mutation: direct and indirect action, comparative evaluation of physical and chemical mutagens.
UNIT-V: Observing mutagen effects in M₁ generation: plant injury, lethality, sterility, chimeras etc., - Observing mutagen effects in M₂ generation - Estimation of mutagenic efficiency and effectiveness spectrum of chlorophyll and viable mutations - Mutations in traits with continuous variation.
UNIT-VI: Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage etc. - Individual plant based mutation analysis and working out effectiveness and efficiency in M₃ generation - Comparative evaluation of physical and chemical mutagens for creation of variability in a same species case studies.
UNIT-VII: Use of mutagens in creating oligogenic and polygenic variations I case studies - In vitro mutagenesis - callus and pollen irradiation - Handling of segregating generations and selection procedures - Validation of mutants - Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc) in different crops - Procedures for micro-mutations breeding/polygenic mutations, Achievements of mutation breeding: varieties released across the world - Problems associated with mutation breeding.
UNIT-VIII: Use of mutagens in genomics, allele mining, TILLING.

Practical
Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity production of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring safety regulations and safe transportation of radioisotopes - Visit to radio isotope laboratory; learning on safe disposal of radioisotopes; Hazards due to chemical mutagens - Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; raising the crop for observation - Mutagenic effectiveness and efficiency; calculating the same from earlier literature - Study of M₁ generation parameters to be observed - Study of M₂ generation parameters to be observed - Mutation breeding in cereals and pulses achievements made and an analysis - Mutation breeding in oilseeds and cotton achievements and opportunities - Mutation breeding in forage crops and vegetatively propagated crops. Procedure for detection of mutations for polygenic traits in M₂ and M₃ generations.

Suggested Readings


GP 507  
**HETEROSIS BREEDING**  2+1  SEM - II  

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

**Theory**

**UNIT-I:** Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and bred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops.

**UNIT-II:** Pre Mendelian and Post Mendelian ideas - Genetic theories of heterosis - Physiological, biochemical and molecular factors underlying heterosis; theories and their estimation - Evolutionary concepts of heterosis.

**UNIT-III:** Prediction of heterosis from various crosses - Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis - Case studies - Relationship between genetic distance and expression of heterosis - case studies; Divergence and Genetic Distance analyses - morphological and molecular genetic distance in predicting heterosis.

**UNIT-IV:** Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

**UNIT-V:** Types of male sterility and use in heterosis breeding, Maintenance, transfer and restoration of different types of male sterility. Use of self-incompatibility in development of hybrids. Hybrid seed production system: 3-line, 2-line and 1-line system, Development of inbreds and parental lines - A, B and R lines - functional male sterility, Commercial exploitation of heterosis - maintenance breeding of parental lines in hybrids.

**UNIT-VI:** Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops - Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops - Problems and prospects, Apomixis in fixing heterosis-concept of single line hybrid.

**UNIT-VII:** Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

**Practical**

Male sterile line characterization in millets; using morphological descriptors - restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton; problems in creation of CGMS system; ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters - Hybrid seed production in field crops - an account on the released hybrids; their potential; problems and ways of overcoming it; hybrid breeding at National and International level; opportunities ahead.

**Suggested Readings**

*Abstracts of the Genetics and Exploitation of Heterosis in Crops* - An International Symposium CIMMYT.
**Objective**

To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

**Theory**

**UNIT-I:** Introduction: Gene regulation; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

**UNIT-II:** Coordinated genetic regulation—examples; Anthocyanin and gene families in maize; Genetic and molecular basis depending on tissue specificity.

**UNIT-III:** Regeneration in plants and animals; Chromatin and nuclear proteins, chromosomal differentiation, nucleo-cytoplasmic interactions; long-lived mRNA; differentiation in *Acetabularia*; morphogenesis in viruses and bacteria.

**UNIT-IV:** Gene expression; Transposons in plant gene expression, cloning, transposon tagging; Light regulated gene expression: Model systems in *Arabidopsis* and maize; Paramutations and imprinting of genes and genomes.

**UNIT-V:** Repeated DNA sequences; hormone-induced cellular functions in plants and animals; double fertilization; embryo and endosperm development; Tissue differentiation and pattern formation; homeotic genes; Seed storage protein synthesis.

**UNIT-VI:** Transgene expression and gene silencing mechanisms; Regulatory genes horizontal and vertical homology; Transformation; Regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

**UNIT-VII:** Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

**Suggested Readings**


UNIT-IV: Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus: Structure and chemical composition; Cell division and physiology of cell division.
UNIT-V: Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes; DNA content variation, types of DNA sequences: unique and repetitive sequences; Organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Suggested Readings

GP 510  BIOTECHNOLOGY FOR CROP IMPROVEMENT  3+1  SEM - I

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

Theory
UNIT-I: Biotechnology and its relevance in agriculture, Definitions, Terminologies and scope in plant breeding.
UNIT-II: Tissue culture- History, callus, suspension cultures, cloning, Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.
UNIT-III: Genotyping; sequencing techniques; Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).
UNIT-IV: Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics, Gene pyramiding.
UNIT-V: Marker assisted selection and molecular breeding, Genomics and genoinformatics for crop improvement, Integrating functional genomics information on agronomically/economically important traits in plant breeding.
UNIT-VI: Recombinant DNA technology, transgenes, method of gene transformations, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial release
UNIT-VII: Biotechnology applications in male sterility/hybrid breeding, molecular farming.
UNIT-VIII: MOs related issues (risk and regulations). GMO; International regulations, Biosafety issues of GMOs, Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights
UNIT-IX: Bioinformatics & Bioinformatics tools.
UNIT-X: Nanotechnology and its applications in crop improvement programmes.

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

GP 511 BREEDING FOR BIOTIC, ABIOTIC STRESS RESISTANCE 2+1 SEM - II

Objective
To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress resistant varieties.

Theory
UNIT-I: Importance of plant breeding with special reference to biotic and abiotic stress resistance, Classification of biotic stresses i.e. major pests and diseases of economically important crops - Concepts in insect and pathogen resistance ; analysis and inheritance of resistance variation. Host defence responses to pathogen invasions-biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defense mechanisms against viruses and bacteria.
UNIT-II: Types and genetic mechanisms of resistance to biotic stresses i.e. horizontal and vertical resistance in crop plants. Quantitative resistance/Adult plant resistance and Slow rusting resistance - Classical and; molecular breeding methods - Measuring plant resistance using plant fitness, behavioural, physiological and insect gain studies.
UNIT-III: Phenotypic screening methods for major pests and diseases; recording of observations; correlating the observations using marker data - Gene pyramiding methods and their implications.
UNIT-IV: Classification of abiotic stresses - Stress inducing factors i.e. moisture stress/drought and water logging & submergence; acidity, salinity/alkalinity/sodicity; high/low temperature, wind, etc. Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.
UNIT-V: Genetics of abiotic stress resistance, Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures. Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc. Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.
UNIT-VI: Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops - Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitenases and Bt for diseases and insect pest management- achievements.

Practical
Phenotypic screening techniques for sucking pests and chewing pests i.e. traits to be observed at plant and insect level - Phenotypic screening techniques for nematodes and borers ; ways of combating them; breeding strategies - Weeds i.e. ecological, environmental impacts on the crops; breeding for herbicide resistance - Evaluating the available populations like RIL, NIL etc. for pest resistance ; use of standard MAS procedures - Phenotypic screening methods for diseases caused by fungi and bacteria; symptoms and data recording; use of MAS procedures - Screening forage crops for resistance to sewage water and tannery effluents; quality parameters evaluation - Screening crops for drought and flood resistance; factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity; their effects and breeding strategies - Understanding the climatological parameters and predisposal of biotic and abiotic stress factors; ways of combating them.
Suggested Readings

GP 512        BREEDING CEREALS, FORAGES AND SUGARCANE

Objective
To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

Theory
UNIT-II: Wheat: evolution and distribution of species and forms - wild relatives and germplasm I cytogenetics and genome relationship - Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc - Sorghum: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - Pearl millet: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc.
UNIT-VI: Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.
Practical
Floral biology - emasculation - pollination techniques; Study of range of variation for yield and yield components - study of segregating populations - evaluation - Trait based screening for stress resistance in crops of importance - Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; use of softwares for database management and retrieval. Practical learning on the cultivation of fodder crop species on sewage water; analysing them for yield components and palatability - Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories, learning the practice of value addition; visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

Suggested Readings
Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
Murty DS, Tabo R & Ajay O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India.

GP 513 BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS

Objective
To provide insight into recent advances in improvement of legumes, oilseeds and fibre crops using conventional and modern biotechnological approaches.

Theory
UNIT-I: Pigeonpea: evolution and distribution of species and forms - wild relatives and germplasm - genetics - cytogenetics and genome relationship; morphological and molecular descriptors used for differentiating the accessions - breeding objectives: yield, quality characters, biotic and abiotic stress etc - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.
UNIT-II: Chickpea: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc. Protein quality improvement - conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors.
UNIT-III: Other pulses: Greensgram, blackgram, fieldpea, lentil, lathyrus, cowpea, lablab, mothbean: evolution, cytogenetics and genome relationship, learning the descriptors -
breeding objectives: yield, quality characters, biotic and abiotic stress etc - - interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT-IV: Groundnut: evolution and distribution of species and forms - Groundnut: wild relatives and germplasm - cytogenetics and genome relationship; pod and kernel characters - Groundnut: breeding objectives: yield, quality characters, biotic and abiotic stress etc.

UNIT-V: Rapeseed and Mustard: breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality - characters in different oils - - evolution and distribution of species and forms - wild relatives and germplasm - genetics - cytogenetics and genome relationship.

UNIT-VI: Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality characters - evolution and distribution of species and forms - wild relatives and germplasm - genetics - cytogenetics and genome relationship.


UNIT-VIII: Castor: evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress etc - Hybrid breeding in castor - opportunities, constraints and achievements.


UNIT X: Distinguishing features of the released varieties in pulses, oilseeds and cotton ; Maintenance of seed purity and seed production.

Practical

Use of descriptors for cataloguing - Floral biology - emasculation - pollination techniques; Study of range of variation for yield and yield components - study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops. Attempting crosses between Blackgram and Greengram. Use of descriptors for cataloguing - Floral biology - emasculation - pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: use of descriptors for cataloguing - Floral biology - emasculation - pollination techniques; learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - study of segregating populations - evaluation - Trait based screening for stress resistance - Cotton fibre quality evaluation - conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation - Cotton: Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance - learning the mechanisms of resistance, quantifying the resistance using various parameters; Evaluating the germplasm of cotton for yield, quality and resistance parameters - learning the procedures on development of Bt cotton - Visit to Cotton Technology Laboratory and Spinning Mills - learning on cotton yarn production, its quality evaluation and uses.

Suggested Readings

Objective
To provide insight into recent advances in improvement of quality traits in rice, millets, legumes, oilseeds and forage crops and for physiological efficiency using conventional and modern biotechnological approaches.

Theory
UNIT-I: Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - Breeding for grain quality parameters in rice and its analysis - Golden rice and aromatic rice - breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.
UNIT-II: Breeding for baking qualities in wheat; characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.
UNIT-III: Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize - concept and breeding strategies - Breeding for quality improvement in forage crops - Genetic resource management for sustaining nutritive quality in crops.
UNIT-IV: Breeding for quality in pulses - Breeding for quality in groundnut, sesame, sunflower and minor oilseeds - Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton.
UNIT-V: Genetic engineering protocols for quality improvement - Achievements made - Value addition in crops; classification and importance - Nutritional genomics and Second generation transgenics.

Practical
Grain quality evaluation in rice; correlating ageing and quality improvement in rice - Quality analysis in millets; estimation of antinutritional factors like tannins in different varieties/hybrids; a comparison - Quality parameters evaluation in wheat; Quality parameters evaluation in pulses - Quality parameters evaluation in oilseeds - Value addition in crop plants - Post harvest processing of major field crops - Quality improvement in crops through tissue culture techniques - Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

Suggested Readings
MAINTENANCE BREEDING, CONCEPTS

Objective
To appraise the students about the variety deterioration and steps to maintain the purity of varieties & hybrids and principles of seed production in self and cross pollinated crops.

Theory
UNIT-I: Variety Development and Maintenance - Define variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmer's variety, hybrid, and population; Variety testing, release and notification system in India and abroad.

UNIT-II: DUS testing - DUS Descriptors for major crops - genetic purity concept and maintenance breeding.

UNIT-III: Factors responsible for deterioration of varieties - safeguards during seed production; maintenance of varieties in self and cross-pollination crops - isolation distance; methods of nucleus and breeder seed production; principles of seed production.

UNIT-IV: Generation system of seed multiplication - nucleus, breeders, foundation, certified; Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearl millet, sorghum, maize and ragi etc.); pulses (green gram, black gram, cow pea, pigeon pea, chick pea, field pea, lentil); oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

Practical
Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production - main characteristics of released and notified varieties, hybrids and parental lines; identification of important weeds objectionable weeds; determination of isolation distance and planting ratios in different crops; seed production techniques of varieties in different crops; hybrid seed production technology of important crops.

Suggested Readings
Tunwar NS & Singh SV. 1985. Handbook of Cultivars. ICAR.

GERmplasm COLLECTION, EXCHANGE

Objective
To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants for crop improvement.

Theory
UNIT-I: History and importance of germplasm exploration; distribution and extent of prevalent genetic diversity; phyto-geographical regions/ecological zones and associated diversity; mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT-II: Concept of population and gene pool; variations in population and their classification; gene frequencies in populations, rare and common alleles; gene pool sampling in self and cross pollinated and vegetatively propagated species; non-selective, random and selective sampling strategies; strategies and logistics of plant exploration and
collection; coarse and fine grid surveys; practical problems in plant exploration; use of in vitro methods in germplasm collection.

UNIT-III: Ethnobotanical aspects of PGR; crop botany, farming systems, collecting wild relatives of crop plants; collection and preservation of specimens; importance and use of herbaria and preparation of herbarium specimens.

UNIT-IV: Post-exploration handling of germplasm collections; present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT-V: History, principles, objectives and importance of plant introduction; prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange; documentation and information management. Plant quarantine: introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; pest risk analysis, pest and pathogen information database; quarantine in relation to integrated pest management; economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT-VI: Detection and identification of pests including use of recent techniques like ELISA, PCR etc.; symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; domestic quarantine; seed certification; international linkages in plant quarantine; weaknesses and future thrust.

UNIT-VII: Genetically modified organisms (GMOs) or genetically engineered plants (GEPs): Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment, Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety with GMOs.

**Practical**

Plant exploration and collection; Techniques of coarse and fine grid surveys. Identification of wild relatives of crop plants; Example of collection, cataloguing and preservation of specimens. Sampling techniques of plant materials, visiting ports, airports to study the quarantine regulations. Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging, Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc), Detection of genetically engineered Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

**Suggested Readings**


GP 517  DATABASE MANAGEMENT, EVALUATION  2+1  SEM - II
AND UTILIZATION OF PGR

Objective
To train the students in germplasm data base management using modern tools and softwares.

Theory
UNIT-I: Statistical techniques in management of germplasm, core identification, estimation of sample size during plant explorations, impact of sampling on population structure; sequential sampling for viability estimation, introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and nomograms, estimation of sample size for storage and viability testing.
UNIT-II: Germplasm documentation; basics of computer and operating systems, database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.
UNIT-III: Germplasm management system: global scenario, genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; predictive methods for identification of useful germplasm; characterization of germplasm and evaluation procedures including specific traits, Gene markers and their use in PGR management, germplasm enhancement, prebreeding and utilizing wild species in crop improvement.
UNIT-IV: Management and utilization of germplasm collections; concept of core collection, molecular markers and their use in characterization, evaluation and utilization of genetic resources; pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; harmonizing agro-biodiversity and agricultural development crop diversification; participatory plant breeding.

Practical
Basics of computer and operating systems- identification of useful germplasm; evaluation of crop germplasm, Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing. Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of Characterization of germplasm, Molecular markers and their use in characterization.

Suggested Readings

GP 518/  BREEDING OF MEDICINAL AND  2+1  SEM - II
PSMA 505  AROMATIC CROPS

Objective
To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory
UNIT-I: Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.
UNIT-II: Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.
UNIT-IV: Prospects in breeding of medicinal crops, viz. Chlorophytum sp, Rauwolfia serpentina, Aloe vera, Ocimum sp, Phyllanthus amarus, Solanum sp.

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyplody, Screening of plants for biotic and abiotic stress and environmental pollution, in-vitro breeding in medicinal and aromatic crops.

Suggested Readings
Thakur RS, Fauri HS & Hussain A. 1989. Major Medicinal Plants of India. CSIR.

GP 601

ADVANCED GENETICS

Objective

To acquaint the students about the recent advances in the field of general genetics.

Theory

UNIT-I: Gene regulation in prokaryotes- Lac operon; Gal operon; Arabinose operon, Tryp operon; Repressor versus attenuation; Regulation of lytic and lysogenic phages; Gene regulation in eukaryotes; Genetic control of antibody diversity.
UNIT-II: Regulatory units in yeast; Mechanisms of genetic recombination; Illegitimate and site specific recombination, flagellar antigen switching in Salmonella; mating type switching in S. cerevisiae, Polymorphism; Methods of studying polymorphism at biochemical and DNA level; Genetics of mitochondria and chloroplasts; Discussion on complex loci with reference to gene concept, Discussion on recent topics in the field of genetics.

Suggested Readings
Selected articles from journals.

GP 602

CELLULAR AND CHROMOSOMAL MANIPULATIONS FOR CROP BREEDING

Objective

This course focuses on the advanced techniques in analyzing chromosome structure and manipulations for genome analysis in crop species.

Theory

UNIT-I: Organization and structure of genome - Genome size - Organization of organellar genomes - Nuclear DNA organization - Nuclear and Cytoplasmic genome interactions and signal transduction, 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 in crop evolution.
UNIT-II: Karyotyping - Chromosome banding and chromosome painting - Tracking introgressions using FISH, GISH, localization and mapping of genes/genomic segments - Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.
UNIT-III: Applications of cytogenetical methods for crop improvement; location and mapping of genes on chromosomes: deficiency method; interchange-genetic consequence,
identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; multiple interchanges-use in producing inbreds, transfer of genes-linked marker methods; Duplication - production and use; inversions and location of genes; B/A chromosome translocations and gene location.

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

UNIT-V: Barriers to interspecific and intergeneric hybridization, Behaviour of interspecific and intergeneric crosses; Totipotency of cells - Morphogenesis: in vivo and in vitro - Meristem culture - anther and pollen culture - ovule, ovary, embryo and endosperm culture - protoplast isolation and culture - protoplast fusion, Different pathways of in vitro morphogenesis - organogenesis and somatic embryogenesis - In vitro mutant/somaclone selection for biotic and abiotic stresses.

Suggested Readings

GP 603 ADVANCED BIOMETRICAL AND QUANTITATIVE GENETICS

Objective
Knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

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

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


GP 604     GENOMICS IN PLANT BREEDING     2+1     SEM - II

Objective
To impart practical skills in advanced molecular techniques in genome mapping and development of transgenic crops.

Theory

UNIT-I: Introduction to the plant genome- Plant genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.
UNIT-II: Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding - Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci- Map based cloning of plant genes.
UNIT-IV: Genome sequencing in plants- Principles and Techniques; Applications of sequence information in plant genome analyses - Comparative genomics- Genome Comparison Techniques: Classical and advanced approaches.
UNIT-V: Detection of Single Nucleotide Polymorphism TILLING and Eco-TILLING - Role of transcriptomics, proteomics and metabolomics in linking genome and phenome- Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out studies and high throughput phenotyping.
UNIT-VI: Concept of database development, management and bioinformatics Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization - Comparative genomic hybridization - Comparative analysis of plant genomes using molecular markers - Genetic map construction using molecular markers - Mapping major genes using molecular markers - QTL mapping in plants - Comparison across mapping populations - Understanding the need genetic algorithms in QTL mapping - Plant Genome Databases - Computational tools to explore plant genome databases - Comparative genomics - Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING - DNA Array Technology - Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

Objective
To provide information about collection, maintenance and use of plant genetic resources for crop improvement.

Theory
UNIT-I: 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.

UNIT-II: Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm, introduction and exchange; principles of in vitro and cryopreservation.

UNIT-III: Germplasm conservation- in situ, ex situ, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; registration of plant genetic resources.

UNIT-IV: PGR data base management, multivariate and clustering analysis, description, national and international protocols for PGR management, PGR for food and agriculture (PGRFA), PGR access and benefit sharing. Role of CGIR system in the germplasm exchange; PBR, Farmers rights and privileges. Seed act, sui generis system; geographical indicators, Intellectual property; patents, copyrights, trademarks and trade secrets.

UNIT-V: Journey from wild to domesticate; Genetic enhancement; need for genetic enhancement. Genetic enhancement in pre era and 21st century; Genetic enhancement and plant breeding; reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality.

UNIT-VI: Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of transferred genes and their expression.

UNIT-VII: Post-genomic tools for genetic enhancement of germplasm; prebreeding through chromosome manipulation-Application of biotechnology for Genetic enhancement-Achievements.

UNIT-VIII: Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement/Prebreeding for crop improvement includin hybrid development.

Suggested Readings


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

Theory
UNIT-I: Facts about plant breeding before the discovery of Mendelism; evolutionary concepts of genetics and plant breeding - Flower development and its importance - genes governing the whorls formation and various models proposed - Mating systems and their exploitation in crop breeding; Types of pollination - Mechanisms promoting cross pollination.

UNIT-II: Self-incompatability and sterility - Types of self incompatibility: 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 - Nucleo-cytoplasmic interactions with special reference to male sterility - Genetic, biochemical and molecular bases.

UNIT-III: Population formation by hybridization - Types of population - Mendelian population, gene pool, composites, synthetics etc. Principles and procedures in the formation of a complex population - Genetic basis of population improvement.

UNIT-IV: Selection in self fertilizing crops: Creation of genetic variability selection methods - Selection methods: mass selection, pureline selection, pedigree method (selection in early generations vs advanced generations); backcross, polycross and test cross.


UNIT-VI: Genetic engineering technologies to create male sterility; prospects and problems - Use of self- incompatability and sterility in plant breeding - case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles - concepts and breeding strategies; case studies - Generating new cytonuclear interaction system for diversification of male steriles - Stability of male sterile lines - Environmental influence on sterility - Environmentally Induced Genic Male Sterility (EGMS) - Types of EGMS; influence on their expression; genetic studies - Photo and 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.

Suggested Readings
Agarwal RL. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH.
Objective

To impart knowledge on crop evolutionary aspects and manipulation at ploidy level for crop improvement.

Theory

**UNIT-I:** 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.

**UNIT-II:** Domestication and uniformity - Characteristics of early domestication and changes - Concept of gene pools and crop evolution; Selection and Genetic drift - consequences.

**UNIT-III:** Speciation and domestication - The process of speciation - Reproductive isolation barriers - Genetic differentiation during speciation - Hybridization - speciation and extinction.

**UNIT-IV:** 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.

**UNIT-V:** Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization - Transgenesis in crop evolution - Multifactorial genome - Intragenomic interaction - Intergenomic interaction - Genotype introgression.

**UNIT-VI:** Methods to study crop evolution - Contemporary Methods - Based on morphological features - Cytogenetic analysis - Allozyme variations and crop evolution - DNA markers, genome analysis and comparative genomics.

**UNIT-VII:** Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, use of autoployploids; 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.

Suggested Readings

Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.


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**Objective**

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

**Theory**

**UNIT-I:** Breeding of crop ideotypes, Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

**UNIT-II:** Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode. Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement.

**UNIT-III:** 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.
UNIT-IV: 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.

UNIT-V: Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

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

Suggested Readings

GP 609 ADVANCES IN BREEDING OF MAJOR 3+0 SEM - I FIELD CROPS

Objective
To provide insight into recent advances in improvement of cereals, millets and non cereal crops using conventional and modern biotechnological approaches.

Theory
UNIT-I: History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum, Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.
UNIT-II: Breeding objectives in Rice, Wheat, Maize, Pearlmillet, Sorghum, Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization. Genetics of quantitative and qualitative traits.
UNIT-III: Breeding for Value addition and resistance to abiotic and biotic stresses.
UNIT-IV: Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.
UNIT-V: National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings
Objective
To impart knowledge on the methods of germplasm conservation.

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

UNIT-II: *Ex situ* conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for sending seeds to network of active/working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

UNIT-III: *In vitro* storage, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in vitro* gene bank.

UNIT-IV: Cryopreservation - procedure for handling seeds of orthodox and recalcitrant-cryoprotectants, 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, challenging aheads.

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 NBIPR/NBAGR - study using fruit crops and other horticultural crops.

Suggested Readings
DNA sequencing, DNA restriction and modification; RNA editing; Anti-sense RNA and ribozyme; Synthesis and use of synthetic oligonucleotides.

UNIT-II: Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression; Genetic basis of apoptosis.

UNIT-IV: Transgenic bacteria and bioethics; Gene silencing; Genetic basis of nodulation, nitrogen fixation and competition by rhizobia; Genetic regulation of nitrogen fixation and quorum sensing in rhizobia; Genetics of mitochondria and chloroplasts.

Practical
Preparation and sterilization of liquid and agar bacterial nutrient media; Assessment of generation time in the log-phase bacterial cultures; Handling of microorganisms for genetic experiments; Isolation of rhizobia from nodules; Gram staining of rhizobial cells; Examination of polyhydroxy butyrate (PHB) production in rhizobia; Demonstration of N2-fixing nodules/bacterial inoculation in the legume-Rhizobium symbiotic system; Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria; Determination of spontaneous and induced mutation frequencies; Discrete bacterial colony counts for the preparation of survival curves and determination of LD50 of a mutagen; Tn-mediated mutagenesis; Analysis and isolation of plasmid DNA; Curing of plasmids.

Suggested Readings
aromatic plants, Physical and chemical mutagens, Induction of polyploidy, Screening of plants for biotic and abiotic stresses and environmental pollution, \textit{in-vitro} breeding in flower crops, medicinal and aromatic crops.

**Suggested Readings**


Handa SS & Kaul MK. 1982. \textit{Cultivation and Utilization of Medicinal Plants}. NISC, CSIR.


Thakur RS, Pauri HS & Hussain A. 1989. \textit{Major Medicinal Plants of India}. CSIR.
GENETICS AND PLANT BREEDING

List of Journals

- Australian Journal of Agricultural Research, Australia
- Australian Journal of Biological Sciences, Australia
- Biometrics, UK
- BioTechniques
- Breeding Science, Japan
- Cereal Research Communication, Hungary
- Cotton Research and Development, Hisar, India
- Critical Reviews in Plant Sciences
- Crop Improvement, Ludhiana
- Crop Science, USA
- Current Science, Bangalore
- Czech Journal of Plant Breeding Genetics, Prague,
- Electronic Journal of Biotechnology
- Euphytica, The Netherlands
- FABIS Newsletter
- Forage Research, Hisar, India
- Genetic resources and crop evolution, Netherlands
- Genetics, USA
- Genome, Canada
- Haryana Agricultural University Journal of Research, Hisar, India
- Heredity
- Hilgardia, Sweden,
- Indian Journal of Agricultural Research, New Delhi
- Indian Journal of Genetics and Plant Breeding, New Delhi
- Indian Journal of Plant Genetic Resources, New Delhi
- International Chickpea Newsletter, ICRISAT
- International Rice Research Notes, IRRI, Philippines
- Journal of Agricultural Research, U.K.
- Journal of Biochemistry and Biotechnology, New Delhi
- Journal of Genetics and Breeding, Italy
- Journal of Heredity
- Journal of Pulses Research, Kanpur
- Legume Research, Karnal
- Madras Agricultural Journal, Coimbatore, India
- MILWAI Newsletter
- Molecular Breeding, USA
- Mutation Research
- National Journal of Plant Sciences, Hisar, India
- Nucleic Acids Research, USA
- Oryza, Cuttack, India
- PGR Newsletter, Syria
- Plant Breeding, Germany
- Plant Molecular Biology, The Netherlands
- Rachis, Syria
- Sorghum and Millet Newsletter, ICRISAT
- Theoretical and Applied Genetics, Germany
### e-Resources

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<td>Breeding Science</td>
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<td>Journal of Biosciences</td>
<td><a href="http://www.ias.ac.in/jbiosci/index.html">http://www.ias.ac.in/jbiosci/index.html</a></td>
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<td>Journal of Genetics</td>
<td><a href="http://www.ias.ac.in/jgenet/index.html">http://www.ias.ac.in/jgenet/index.html</a></td>
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<td>Tropicultura</td>
<td><a href="http://www.bib.fsagx.ac.be/tropicultura/">http://www.bib.fsagx.ac.be/tropicultura/</a></td>
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<td>Turkish Journal of Agriculture and Forestry Sciences</td>
<td><a href="http://journals.tubitak.gov.tr/agriculture/index.php">http://journals.tubitak.gov.tr/agriculture/index.php</a></td>
</tr>
</tbody>
</table>

### Other Major Portals for Genetics and Plant Breeding

- [http://www.icrisat.org/](http://www.icrisat.org/)
- [http://121.244.161.11/Search/QuickSearch.asp](http://121.244.161.11/Search/QuickSearch.asp)
- [http://www.plantstress.com/WRFiles/literaturewr.htm](http://www.plantstress.com/WRFiles/literaturewr.htm) (portal for several sites)
- [http://www2.unil.ch/lpc/docs/index_plants.htm](http://www2.unil.ch/lpc/docs/index_plants.htm) (portal for several sites)
- [http://www.dnaftb.org/dnaftb/](http://www.dnaftb.org/dnaftb/) (portal for several sites)

### Suggested Broad Areas for Master’s and Doctoral Research

- Studies on stay-green traits in relation to genes affecting efficiency of photosynthesis, biotic/abiotic stress tolerance
- Genetics of AGP system for better photosynthesis and translocation
- Identification of genes/QTLs for NUE and WUE
- Molecular markers tagged to genes/QTLs identified for improvement of nutrient use efficiency, water use efficiency and stress tolerance
- MAS based mobilization of transgenes for tolerance to biotic and abiotic stresses into desirable agronomic backgrounds
- Breeding methodologies to enhance selection efficiency
- Component approaches and development of selection criteria for quantitative trait improvement
- Stability analyses and methods to estimate the G X E components in breeding materials
- Relative efficiency analyses of genetic component estimation for reliable use in developing selection criteria in crop plants
- Distance and divergence statistics for identification of similarity assessment among genetic stocks and parental genetic material
- Dependable marker systems for detection of introgression in wide crosses with minimized linkage drag
- Analysis of Resistance Gene analogues and their use in MAS with enhanced disease resistance
- Analysis of Gene analogues and expression synteny and their use in MAS with enhanced quality and trait expression
- Refinements in embryo rescue and consequent diplodization for production of double haploids
• Breeding through distant hybridization route for New Plant Type for breaking yield barriers
• Genetics of durable, quantitative resistance and adult plant resistance in major crops against known pathogens
• Development of tools and methodologies for identification of genes responsible for resistance against polyphagus insects
• Localization of genes responsible for specific trait expression using disomic chromosome substitution lines
• Induction of novel variation through mutagenesis tools and identify novel genes for different traits
• Development of heterotic pools for maximized heterosis in cross and self pollinated crops where hybrid seed production tools are available
• Genetics and traits responsible for terminal and initial heat tolerance in wheat, maize and mustard
• Genetics of cold tolerance related traits in Brassica maize, rice and pigeonpea
• Widening the QPM base in maize and prebreeding to add value to the genetic stocks of QPM
• Comparison of relative efficiency of different softwares in analysis of quantitative trait loci and linkages
• Characterization of germplasm using key descriptors at morphological and molecular levels
• Identification of descriptors in crops
• Development of recombinant inbred lines and mapping populations
  • Floral biology of underutilized and medicinal and aromatic plants
## HORTICULTURE
### FLORICULTURE AND LANDSCAPE ARCHITECTURE

#### Course Structure

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<th>SEM</th>
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<tbody>
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<td>BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS</td>
<td>2+1</td>
<td>I</td>
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<tr>
<td>FLA 502*</td>
<td>PRODUCTION TECHNOLOGY OF CUT FLOWERS</td>
<td>2+1</td>
<td>I</td>
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<tr>
<td>FLA 503*</td>
<td>PRODUCTION TECHNOLOGY OF LOOSE FLOWERS</td>
<td>2+1</td>
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<tr>
<td>FLA 504*</td>
<td>LANDSCAPING AND ORNAMENTAL GARDENING</td>
<td>2+1</td>
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<td>FLA 505*</td>
<td>PROTECTED FLORICULTURE</td>
<td>2+1</td>
<td>II</td>
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<td>FLA 506*</td>
<td>VALUE ADDITION IN FLOWERS</td>
<td>2+1</td>
<td>II</td>
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<td>FLA 507</td>
<td>TURFING AND TURF MANAGEMENT</td>
<td>2+1</td>
<td>I</td>
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<td>FLA 508</td>
<td>CAD FOR OUTDOOR AND INDOORSCAPING</td>
<td>2+1</td>
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<td>FLA 602**</td>
<td>ADVANCES IN FLOWER PRODUCTION TECHNOLOGY</td>
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<td>FLA 603</td>
<td>ADVANCES IN PROTECTED AND PRECISION FLORICULTURE</td>
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<td>FLA 604**</td>
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<td>FLA 605/MBB 604/VSC 604</td>
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### SERVICE COURSE

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<tr>
<td>ABM 534</td>
<td>MANAGEMENT OF FLORICULTURE AND LANDSCAPING</td>
<td>2+0</td>
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</table>

*Compulsory for Master's programme; ** Compulsory for Doctoral programme

One course of Genetics & Plant Breeding of 3 credits is compulsory as Minor/Supporting

To be taught by: ¹ Floriculture & Landscape Architecture and Computer Section; ² Molecular Biology and Biotechnology
FLORICULTURE AND LANDSCAPE ARCHITECTURE

Course Structure

FLA 501  BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS  2+1  SEM - I

Objective
To impart comprehensive knowledge about the principles and practices of breeding of flower crops and ornamental plants.

Theory
UNIT-I: Principles -- Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India.
UNIT-II: Genetic inheritance -- of flower colour, doubleness, flower size, fragrance, post harvest life.
UNIT-III: Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.
UNIT-IV: Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, lilies, nerium.
UNIT-V: Breeding constraints and achievements made in ornamental plants -- petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages Intoduction and selection of plants for waterscaping and xeriscaping.

Practical
Description of botanical features Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, in vitro breeding in flower crops and ornamental plants.

Suggested Readings

FLA 502  PRODUCTION TECHNOLOGY OF CUT FLOWERS  2+1  SEM - I

Objective
To impart basic knowledge about the importance and production technology of cut flowers grown in India.

Theory
UNIT-I: Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India-Patent rights, nursery management, media for nursery, special nursery practices.
UNIT-II: Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO₂ on growth and flowering.
UNIT-III: Flower production і water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.
UNIT-IV: Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.
UNIT-V: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops
Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlias, gypsophilla, limonium, statices, stock, cut foliages.

Practical
Description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings
Chadha KL & Chaudhury B. 1992. Ornamental Horticulture in India. ICAR.
Chadha KL & Chaudhury B.1992. Ornamental Horticulture in India. ICAR.

FLA 504 LANDSCAPING AND ORNAMENTAL 2+1 SEM - I GARDENING

Objective
Familiarization with principles and practices of landscaping and ornamental gardening.

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

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

Suggested Readings

FLA 505 PROTECTED FLORICULTURE 2 + 1 SEM - II

Objective
Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

Theory
UNIT-I: Prospects of protected floriculture in India; Types of protected structures ï Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures ï economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation.
UNIT-I: Environment control – management and manipulation of temperature, light, humidity, air and CO₂; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

UNIT-II: Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM.

UNIT-IV: Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT-V: Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

Practical

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, post-harvest handling, packing methods, project preparation, visit to commercial greenhouses.

Suggested Readings


FLA 506

VALUE ADDITION IN FLOWERS 2+1 SEM - II

Objective

To develop understanding of the scope and ways of value addition in flowers.

Theory

UNIT-I: Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.
UNIT-II: Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations.
UNIT-III: Dry flowers Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making Î Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement Î dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.
UNIT-IV: Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

Practical

Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc.; Visit to dry flower units, concrete and essential oil extraction units.
Suggested Readings

**FLA 507**  
**TURFING AND TURF MANAGEMENT**  
2+1  
SEM - I

**Objective**
To develop understanding of the principles and management of turfing.

**Theory**

UNIT-I: Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT-II: Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens.

UNIT-III: Preparatory operations; Growing media used for turf grasses - Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT-IV: Turf management - Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing - mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT-V: Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

**Practical**
Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices - mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics.

**Suggested Readings**

**FLA 508**  
**CAD FOR OUTDOOR AND INDOORSCAPING**  
2+1  
SEM - II

(To be taught jointly by Floriculture & Landscape Architecture and Computer Section)

**Objective**
To impart basic knowledge about the operation of Computer Aided Designing (CAD) in landscape garden designing.

**Theory**

UNIT-I: Exposure to CAD (Computer Aided Designing) - Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

UNIT-II: 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects.


UNIT-IV: 3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

UNIT-V: ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data
management, plotting and accessories for designing. Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

**Practical**

Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments, Isometric drawings, Using productivity tools, Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden, Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD, Organization, dimensioning, detailing and visualization tools with ARCHICAD, Using Photoshop package for 3D picture insertion, Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots.

**Suggested Readings**


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**FLA 601 **

**ADVANCES IN BREEDING OF FLOWER CROPS**

**Objective**

To update knowledge on the recent research trends in the field of breeding of flower crops with special emphasis on crops grown in India.

**Theory**

UNIT-I: Origin and evolution of varieties, distribution, Genetic resources, genetic divergence, Plant introduction, selection and domestication, Inheritance of important characters, Genetic mechanisms associated with flower colour and flower size, doubleness, fragrance and post-harvest life, Plant Variety Protection Act.

UNIT-II: Specific objectives of breeding in flower crops, Methods of breeding suited to seed and vegetatively propagated flower crops, Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility-Incompatibility problems, *In Vtro* breeding.

UNIT-III: Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops.

UNIT-IV: Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladioli, orchids and anthurium.

UNIT-V: Specific breeding problems and achievements made in aster, petunia, liliums, heliconia, bird of paradise, hibiscus and bougainvillea.

**Practical**

Description of crops and cultivars; Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies; Induction of mutants; Physical and chemical mutagens; Induction of polyploidy; Screening of plants for biotic and abiotic stresses and environmental pollution; *in-vitro* breeding in flower crops.

**Suggested Readings**


Choudhary RC.1993. *Introduction to Plant Breeding*. Oxford & IBH.


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**FLA 602 **

**ADVANCES IN FLOWER PRODUCTION TECHNOLOGY**

**Objective**

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

**Theory**

UNIT-I: Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; Special characteristics and requirements; cut flower, loose flowers, dry flowers and floral oil trade.

UNIT-II: Propagation and multiplication; IPR issues related to propagation of materials; Greenhouse management; Soil/media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of
environmental parameters, light, temperature, moisture, humidity and CO₂ on growth and flowering; regulation for quality flowers.

UNIT-II: Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Precooling, pulsing, packing, marketing; Export potential; Agri Export Zones.

UNIT-IV: Crop specific practices – rose, anthurium, orchids, carnation, gladioli, gerbera, liliums, heliconia, bird of paradise, Jasminum sp., marigold, tuberose, crossandra.

UNIT-V: Floral oil industry, floral concrete production, extraction methods, recent advances.

Practical

Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Microirrigation; Nutrition and fertigation. Special practices– Pinching, netting, disbudding, defoliation and chemical pruning; Photoperiodic and chemical induction of flowering; Assessing harvest indices; Post-harvest handling; Tissue analysis; Extraction of floral concrete and oils; case studies; visit to commercial cut flower units.

Suggested Readings


FLA 603 ADVANCES IN PROTECTED AND PRECISION FLORICULTURE

Objective

Appraisal on the advances in protected and precision farming of flower crops.

Theory

UNIT-I: Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.

UNIT-II: Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques.

UNIT-III: Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliums, cut foliage; Harvest indices – harvesting, PH handling, marketing, export.

UNIT-IV: Precision floriculture, Principles and concepts, Enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors.


Practical

Growing structures, basic considerations in establishment and operation of greenhouses, Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques, Crop regulation, special horticultural practices under protected cultivation, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Suggested Readings

**FLA 604 ADVANCES IN LANDSCAPE ARCHITECTURE 1+2 SEM - II**

**Objective**
To update knowledge on the recent trends in the field of landscape architecture and developing practical skills.

**Theory**

UNIT-I: Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types.

UNIT-II: Expenses to model landscaping units of all category, Creativity and communication skills for landscape architect, Way of designing a commercial landscape project.

UNIT-III: Assessing site and plants adaptability for different locations, Landscape engineering (Topographical) survey and designing concept, special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning).

UNIT-IV: Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD).

UNIT-V: Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget / Project cost estimating, Execution strategies, Assessing a successful design in site.

**Practical**
Commercial landscaping, Plant identification, Materials of garden design, Design making by different garden styles and types. Way of designing a commercial landscape project, visit to model ornamental nursery, Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept). Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD).

**Suggested Readings**

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**FLA 605/MBB 604/VSC 604 ADVANCES IN CROP BIOTECHNOLOGY 3+0 SEM - I**
(To be taught by Molecular Biology and Biotechnology)

**Objective**
To discuss specialized topics on the application of molecular tools in breeding of specific crops.

**Theory**

UNIT-I: Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available tissue culture, transformation, molecular marker and genomic tools for crop improvement.

UNIT-II: 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).

UNIT-III: Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/trait; selected examples on marker assisted selection of qualitative and quantitative traits.

UNIT-IV: Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major horticultural crops.

**Suggested Readings**
Selected articles from journals.
FLORICULTURE AND LANDSCAPE ARCHITECTURE

List of Journals & Magazines

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

Suggested Broad Topics for Master’s and Doctoral Research

- Micro-propagation of major flower crops
- Application of genetic engineering in flower crops
- Use of molecular markers in flower crops
- Flower crops improvement
- Crop selection for biotic and abiotic stresses
- Diagnostic and recommended integrated system in floriculture
- Precision farming in floriculture
- Protected cultivation of flower crops
- Post-harvest management of flower crops
- Nutritional and water requirements of flower crops
# FRUIT SCIENCE

## Course Structure

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<thead>
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<tr>
<td>FSC 501*</td>
<td>TROPICAL AND DRY LAND FRUIT PRODUCTION</td>
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<td>I</td>
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<tr>
<td>FSC 502*</td>
<td>SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION</td>
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## SERVICE COURSES

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*Compulsory for Master’s programme; ** Compulsory for Doctoral programme

One course of Genetics & Plant Breeding of 3 credits is compulsory as Minor/Supporting

To be taught by: ➊ Molecular Biology and Biotechnology; ➋ Agricultural Meteorology; ➌ Bioinformatics, Molecular Biology & Biotechnology and Animal Biotechnology
FRUIT SCIENCE

Course Structure

FSC 501  TROPICAL AND DRY LAND FRUIT PRODUCTION  2+1  SEM - I

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

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

Crops
UNIT-I: Mango and Banana
UNIT-II: Citrus and Papaya
UNIT-III: Guava, Sapota and Jackfruit
UNIT-IV: Pineapple, Annonas and Avocado
UNIT-V: Aonla, Pomegranate and Ber, minor fruits of tropics

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

Suggested Readings
Nakasone HY & Paul RE. 1998. Tropical Fruits. CABI.

FSC 502  SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION  2+1  SEM - II

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

Theory
Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.
Crops
UNIT-I: Apple, pear, quince, grapes
UNIT-II: Plums, peach, apricot, cherries
UNIT-III: Litchi, loquat, persimmon, kiwifruit, strawberry
UNIT-IV: Nuts - walnut, almond, pistachio, pecan, hazelnut
UNIT-V: Minor fruits - mangosteen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate

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

Suggested Readings
Nijjar GS. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.

FSC 503  BIODIVERSITY AND CONSERVATION  2+1  SEM - II  OF FRUIT CROPS

Objective
Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory
UNIT-I: Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity.
UNIT-II: Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources - conservation in situ and ex situ.
UNIT-III: Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.
UNIT-IV: Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.
UNIT-V: GIS and documentation of local biodiversity, Geographical indication.

Crops
Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, Prunus sp, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical
Documentation of germplasm - maintenance of passport data and other records of accessions; field exploration trips, exercise on ex situ conservation - cold storage, pollen/seed storage, cryopreservation, visits to National Gene Bank and other centers of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Suggested Readings
FSC 504  CANOPY MANAGEMENT IN FRUIT CROPS  1+1  SEM - II

Objective
To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory
UNIT-I: Canopy management - importance and advantages; factors affecting canopy development.
UNIT-II: Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.
UNIT-III: Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion.
UNIT-IV: Canopy management through plant growth inhibitors, training and pruning and management practices.
UNIT-V: Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practical
Study of different types of canopies, training of plants for different canopy types, canopy development through pruning, use of plant growth inhibitors, geometry of planting; study on effect of different canopy types on production and quality of fruits.

Suggested Readings

FSC 505  PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS  2+1  SEM - I

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

Theory

Practical
Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening case studies, micropropagation, explant preparation, media preparation, culturing – in vitro clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.
Suggested Readings


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**FSC 506**

**BREEDING OF FRUIT CROPS**

**2+1**

**SEM - I**

**Objective**

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

**Theory**

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

**Crops**

**UNIT-I**: Mango, banana and pineapple

**UNIT-II**: Citrus, grapes, guava and sapota

**UNIT-III**: Jackfruit, papaya, custard apple, aonla, avocado and ber

**UNIT-IV**: Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts

**UNIT-V**: Apple, pear, plums, peach, apricot, cherries and strawberry

**Practical**

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits.

**Suggested Readings**


Nijjar GS. 1977. (Eds.). *Fruit Breeding in India*. Oxford & IBH.


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**FSC 507**

**POST HARVEST TECHNOLOGY FOR FRUIT CROPS**

**2+1**

**SEM - II**

**Objective**

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

**Theory**

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

**UNIT-II**: Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

**UNIT-III**: Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

**UNIT-IV**: Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.
UNIT-V: Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

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

Suggested Readings

FSC 508  GROWTH AND DEVELOPMENT OF  2+1  SEM - I  HORTICULTURAL CROPS

Objective
To develop understanding of growth and development of horticultural crops which have implications in their management.

Theory
UNIT-I: Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis.
UNIT-II: Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.
UNIT-III: Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brassinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors.
UNIT-IV: Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.
UNIT-V: Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practical
Understanding dormancy mechanisms in seeds, tubers and bulbs and stratification of seeds, tubers and bulbs, visit to arid, subtropical and temperate horticultural zones to identify growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables, study of impact of physical manipulations on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development.

Suggested Readings
FSC 509/ MBB 515
BIOTECHNOLOGY OF HORTICULTURAL CROPS

(To be taught by Molecular Biology & Biotechnology)

Objective
Understanding the principles, theoretical aspects and developing skills in biotechnology of horticultural crops.

Theory
UNIT-I: Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.
UNIT-II: Callus culture - types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis.
UNIT-IV: Physiology of hardening - hardening and field transfer, organ culture ï meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion.

Practical
An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, protoplast isolation and culture, genetic transformation.

Suggested Readings
FSC 510  ORGANIC HORTICULTURE  1+1  SEM - I

Objective
To develop understanding of organic horticulture production system including GAP.

Theory
UNIT-I: Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits.
UNIT-II: Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.
UNIT-IV: GAP - Principles and management, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.
UNIT-V: Constraints in certification, organic horticulture and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

Practical
Features of organic orchards, working out conversion plan, Input analysis- manures, nutrient status assessment of manures, biocomposting, biofertilizers and their application, panchagavya preparation and other organic nutrients application, methods of preparation of compost, vermicompost, green manuring, preparation of neem products and application, BD preparations and their role, EM technology and products, biological/natural control of pests and diseases, soil solarization, frame work for GAP, case studies, HACCP analysis, residue analysis in organic products, documentation for certification, visit to fields cultivated under organic practices.

Suggested Readings
Gaur AC, Neblakantan S & Dargan KS. 1984 Organic Manures. ICAR.

FSC 511  PROTECTED FRUIT CULTURE  2+1  SEM - I

Objective
Understanding the principles, theoretical aspects and developing skills in protected cultivation of fruit crops.

Theory
UNIT-I: Greenhouse - World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth.
UNIT-II: Basics of greenhouse design, different types of structures - greenhouse, shade net, poly tunnels - Design and development of low cost greenhouse structures.
UNIT-V: Automated greenhouses, microcontrollers, waste water recycling, Management of pest and diseases - IPM.

Practical
Designs of greenhouse, low cost poly tunnels, nethouse- Regulation of light, temperature, humidity in greenhouses, media, greenhouse cooling systems, ventilation systems, fertigation systems, special management practices, project preparation for greenhouses, visit to greenhouses.

Suggested Readings
Aldrich RA & Bartok JW. 1994. Green House Engineering. NRAES, Riley, Robb Hall,
FSC 512  GAP FOR HORTICULTURAL CROPS  1+0  SEM - II

Objective
To impart comprehensive knowledge about the principles and practices of Good Agricultural Practises (GAP) for horticultural crops.

Theory
UNIT-I: Genesis of GAP - definition/description, components listed by FAO, frame work.
UNIT-II: Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of ways of improving the productivity profitability, and resource efficiency, harvest and post-harvest handling.
UNIT-III: On farm processing, storage, energy and waste management, human health, welfare, safety.
UNIT-IV: Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group- Good Agricultural Practices), EUREP etc.

Suggested Readings

FSC 513/ AGM 507  WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES  2+0  SEM - I
(To be taught by Agro Meteorology)

Objective
To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory
UNIT-I: Historical reviews and theories of weather modification, present status of weather modification for horticulture; atmospheric composition and green house effect.
UNIT-II: Scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.
UNIT-III: Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in horticulture in the region concerned; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.
UNIT-IV: Approaches, tools and strategies to deal with risks; methods for weather and climate related risk assessments; mitigating practices before occurrence; preparedness for the inevitable risks; contingency planning and responses; disaster risk mainstreaming.
UNIT-V: Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; challenges for developing coping strategies including transferring risks through insurance schemes; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings
FSC 601 ADVANCES IN BREEDING OF FRUIT CROPS 2+1 SEM - II

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

Theory
Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits, recent advances in crop improvement efforts - introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

Crops
UNIT-I: Mango and banana
UNIT-II: Papaya, grapes and citrus
UNIT-III: Guava and sapota
UNIT-IV: Pineapple and avocado
UNIT-V: Apple, pear, plums, peaches, apricot, cherries and strawberry

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

Suggested Readings

FSC 602 ADVANCES IN PRODUCTION OF FRUIT CROPS 2+1 SEM - I

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

Theory
National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to
overcome stress effects, integrated and modern approaches in water and nutrient management, Total quality management (TQM) - Current topics.

Crops

UNIT-I: Mango and banana
UNIT-II: Papaya, grapes and citrus
UNIT-III: Guava, sapota and aonla
UNIT-IV: Pineapple, avocado and jack
UNIT-V: Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Suggested Readings

Nakasone HY & Paull RE. 1998. Tropical Fruits. CABI.

FSC 603 ADVANCES IN GROWTH REGULATION 2+1 SEM - II OF FRUIT CROPS

Objective
Appraisal on the advances in growth regulation of fruit crops.

Theory
UNIT-I: Ecophysiological influences on growth and development of fruit crops- flowering, fruit set- Crop load and assimilate partitioning and distribution.
UNIT-II: Root and canopy regulation, study of plant growth regulators in fruit culture-structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.
UNIT-III: Absorption, translocation and degradation of phytohormones ï internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.
UNIT-IV: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.
UNIT-V: Flower drop and thinning, fruitset and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation-current topics.

Practical
Root- shoot studies, quantifying the physiological and biochemical effects of physical and chemical growth regulation, bioassay and isolation through chromatographic analysis for auxins, gibberellins, experiments on growth regulation during propagation, dormancy, flowering, fruitset and fruit development stages.

Suggested Readings

INTRODUCTION TO BIOINFORMATICS 2+1 SEM - I

Objective
To impart an introductory knowledge about the subject of Bioinformatics to the students studying any discipline of science.

Theory
UNIT-I: Introduction, biological databases - primary, secondary and structural, Protein and Gene Information Resources - PIR, SWISSPROT, PDB, GenBank, DDBJ. Specialized genomic resources.
UNIT-II: DNA sequence analysis, cDNA libraries and EST, EST analysis, pair wise alignment techniques, database searching, multiple sequence alignment.
UNIT-III: Secondary database searching, building search protocol, computer aided drug design - basic principles, docking, QSAR.
UNIT-IV: Analysis packages - commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical
i. Usage of NCBI resources
ii. Retrieval of sequence/structure from databases
iii. Visualization of structures
iv. Docking of ligand receptors
v. BLAST exercises.

Suggested Readings

BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS 2+1 SEM - I

Objective
To update knowledge on the recent research trends in the field of biotic and abiotic stress management in horticultural crops.

Theory
UNIT-I: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).
UNIT-II: Pollution - increased level of CO₂, industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.
UNIT-III: Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.
UNIT-IV: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.
UNIT-V: Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

Practical
Seed treatment /hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.
Suggested Readings

Nickell LG. 1983. *Plant Growth Regulating Chemicals*. CRC.
FRUIT SCIENCE

List of Journals & Magazines

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

Suggested Broad Topics for Master’s and Doctoral Research

- Micro-propagation of fruit crops
- Application of genetic engineering in fruit crops
- Use of molecular markers in fruit crops
- Fruit crop improvement
- Crop selection for biotic and abiotic stresses
- Diagnostic and recommended integrated system in cultivation of fruit crops
- Precision farming in fruit crops
- Protected cultivation of fruit crops
- Root distribution studies in fruit crops
- Canopy management in fruit crops
- Organic fruit cultivation
- Post harvest management of fruit crops
- Value addition in fruit crops
- Rejuvenation of orchards
- Replant problems in perennial fruit crops
- Research on burning problems in horticulture crops like mango malformation, citrus decline, guava wilt, alternate bearing, etc.
### NEMATOLOGY

#### Course Structure

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* Compulsory for Master's programme; ** Compulsory for Doctoral programme

One course of Biochemistry or G&PB of 3 credits is compulsory as Minor/Supporting
To be taught by: ❶ Nematology; ❷ Entomology; ❸ Plant Pathology; ❹ Entomology and Plant Pathology
NEMATOLOGY

Course Contents

NEMA 501 PRINCIPLES OF NEMATOLOGY 2+1 SEM - 1

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

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

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

Suggested Readings
Perry RN & Moens M. 2006. Plant Nematology. CABI.
Walia RK & Bajaj HK. 2003. Text Book on Introductory Plant Nematology. ICAR.

NEM 502/ ENT 503 PRINCIPLES OF TAXONOMY 2+0 SEM - 1

Objective
To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory
UNIT-I: Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods- character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.
UNIT-II: Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

Suggested Readings
NEMA 503  
STRUCTURAL AND FUNCTIONAL ORGANIZATION OF NEMATODES

Objective
Familiarization with structural organization of nematode body so as to enable the students to understand biology, physiology and classification of nematodes.

Theory
UNIT-I: Introduction and general organization of nematode body.
UNIT-II: Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.
UNIT-III: Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.
UNIT-IV: Reproductive system- terminology and variations in female and male reproductive systems, nemic eggs and sperms, types of reproduction, spermatogenesis and oogenesis.
UNIT-V: Types and structure of excretory-secretory systems; nervous system and associated sense organs.

Practical
Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.

Suggested Readings

NEMA 504  
CLASSIFICATION OF NEMATODES

Objective
Development of skills in the identification of plant parasitic nematodes up to genera and species levels.

Theory
UNIT-I: Principles of nematode systematics.
UNIT-II: Placement of nematodes in Animal Kingdom and comparison with related organisms.
UNIT-III: Classification of Phylum Nematoda- Orders of Class Adenophorea and Secernentea; Diagnosis of Order Tylenchida- Suborder Tylenchina, Hoplolaimina and Criconematina; Infraorders Tylenchata and Anguinata- their families and genera.
UNIT-IV: Diagnosis of genera and families of Suborders Hoplolaimina and Criconematina.
UNIT-V: Orders Aphelenchida, Dorylaimida, Triplonchida, Rhabditida with emphasis on economically important taxa.

Practical
Identification of common plant parasitic nematodes belonging to Orders Tylenchida, Dorylaimida, Aphelenchida and Triplonchida up to generic level; and up to species level for major nematode pests (root-knot, cyst nematodes etc.) of crops. Identification of EPNs belonging to Order Rhabditida.

Suggested Readings
Hunt DJ. 1993. Aphelenchida, Longidoridae and Trichodorididae – their Systematics and Bionomcs. CABI
Siddiqi MR. 2000. Tylenchida: Parasites of Plants and Insects. 2nd Ed. CABI.

NEMA 505  
NEMATOLOGICAL TECHNIQUES

Objective
Understanding the principles, theoretical aspects and developing skills in nematological techniques.
Theory

UNIT-I: Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.
UNIT-II: Survey and surveillance methods; collection of soil and plant samples; techniques for extraction of nematodes from soil and plant material; estimation of population densities.
UNIT-III: Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.
UNIT-IV: In vitro and in vivo culturing techniques of plant parasitic, bacteriophagous, mycophagous and omnivorous nematodes.
UNIT-V: Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.
UNIT-VI: Application of molecular techniques in Nematology.

Practical

Collection of soil and plant samples; extraction of nematodes from soil by Baermann funnel, sieving and decanting, elutriation and sugar centrifugal methods; extraction of cysts from soil; extraction of nematodes from plant material; estimation of population densities; staining plant material for nematodes; killing and fixing nematodes, clearing nematodes by slow and Seinhorst's method; preparation of temporary and permanent mounts; measurements, drawing, microphotography, special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections; collection of root exudates, preparation of exhibits of nematode diseased plant material, in vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

Suggested Readings


NEMA 506 NEMATODE DISEASES OF CROPS 3+1 SEM - II

Objective

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

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.
UNIT-I: Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum. Other nematodes of minor importance.
UNIT-II: Pulses, Sugarcane, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems. Other nematodes of minor importance.
UNIT-IV: Fruit crops- root-knot disease, reniform nematode, slow decline of citrus, spreading decline of citrus. Mushroom- nematode problems. Other nematodes of minor importance.
Practical
Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.

Suggested Readings
Perry RN & Moens M. 2006. Plant Nematology. CABI.

NEMA 507 NEMATODE BIOLOGY AND PHYSIOLOGY 2+1 SEM - II
Objective
To develop understanding of life cycle patterns, feeding and metabolic processes in phytonematodes which have implications in their management.

Theory
UNIT-I: Host finding and invasion, feeding, hatching, molting; life cycle patterns in different types of nematodes.
UNIT-II: Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.
UNIT-III: Chemical composition of nematodes, hydrolytic enzymes, pseudocoelome and function of transport.
UNIT-IV: Physiology of digestive system, intermediary metabolism.
UNIT-V: Osmoregulation, physiology of excretory-secretory and neuromuscular systems.

Practical
Studies on embryogenesis and post-embryogenesis, hatching, molting, life cycle development, feeding, enzymatic assay by electrophoresis.

Suggested Readings

NEMA 508 NEMATODE ECOLOGY 2+1 SEM - II
Objective
To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

Theory
UNIT-I: Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.
UNIT-II: Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.
UNIT-III: Effects of abiotic and biotic factors on nematodes.
UNIT-IV: Environmental extremes and nematode behaviour- aggregation, swarming, orientation, feeding and reproduction.
UNIT-V: Survival strategies of nematodes in adverse environment and absence of host.
UNIT-V: Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

Practical
Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.
Suggested Readings

**NEMA 509  NEMATODE INTERACTIONS WITH 1+1 SEM - II OTHER ORGANISMS**

**Objective**
To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

**Theory**
- **UNIT-I**: Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.
- **UNIT-II**: Interaction of plant parasitic nematodes with wilt causing fungal pathogens.
- **UNIT-III**: Interaction of plant parasitic nematodes with root rot and other fungal pathogens.
- **UNIT-IV**: Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.
- **UNIT-V**: Virus transmission by nematodes.

**Practical**
Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens.

**Suggested Readings**

**NEMA 510  NEMATODE MANAGEMENT 2+1 SEM - II**

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

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

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


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**NEMA 511**  
**BENEFICIAL NEMATODES**  
**1+1**  
**SEM - I**  

**Objective**

To sensitize about the use of nematodes for the biological control of insect pests of crops, and application of some nematodes as biological models and as indicators of environmental pollution.

**Theory**

UNIT-I: Beneficial nematode fauna- predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode-insect associations; taxonomic characteristics of nematode parasites of insects.

UNIT-II: Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.

UNIT-III: Entomopathogenic nematodes- *Steinernema* and *Heterorhabditis*, their morphological characteristics, taxonomic status, biology and mode of action.

UNIT-IV: Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

UNIT-V: Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.

**Practical**

Isolation, identification, mass rearing and application methods of entomopathogenic nematodes.

**Suggested Readings**


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**NEMA 512/ENT 510**  
**PRINCIPLES OF INTEGRATED PEST MANAGEMENT**  
**1+1**  
**SEM - I**  

*(To be taught by Entomology)*

**Objective**

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

**Theory**

UNIT-I: History and origin, definition and evolution of various related terminologies.

UNIT-II: Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT-III: Tools of pest management and their integration- legislative, cultural, biological, physical and mechanical methods; pest survey and surveillance, forecasting, types of
surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

UNIT-IV: Components, classification, bases and mechanisms of host plant resistance; screening techniques, breeding methods including transgenics and importance of plant resistance in IPM.

Practical
Characterization of agro-ecosystems; demonstration of plant resistance in important crops; crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Readings

NEMA 513/PL PATH 513
DISEASE RESISTANCE IN PLANTS 2+0 SEM - II
(To be taught by Plant Pathology)

Objective
To acquaint with disease resistance mechanisms in plants.

Theory
UNIT-I: Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.
UNIT-II: Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.
UNIT-III: Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

Suggested Readings
NEM 514/ PLANT QUARANTINE 2+0 SEM - II
ENT 520/ (To be taught by Entomology)
PL. PATH. 520

Objective
To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory
UNIT-I: Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.
UNIT-III: Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfection/salvaging of infected material.
UNIT-IV: WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

NEMA 601 ADVANCES IN STRUCTURE AND SYSTEMATICS OF NEMATODES 2+1 SEM - I

Objective
Studies on the ultrastructure of plant parasitic nematodes based on TEM and SEM, and appraisal of recent developments in their classification.

Theory
UNIT-I: Ultrastructure of nematode body wall- cuticle, hypodermis and muscles; nematode feeding apparatus, and other parts of alimentary canal.
UNIT-II: Ultrastructure of nematode sense organs, reproductive and excretory-secretory systems.
UNIT-III: Principles and rules of nomenclature and classification; preparation of illustrations, keys and compendia for nematode species and other taxa.
UNIT-IV: Non-conventional approaches of nematode identification- molecular, biochemical, immunodiagnostic, molecular characterization and DNA finger-printing techniques.
UNIT-V: Development of computer-based nematode identification programmes.

Practical
Detailed studies of morphological structures and identification of plant parasitic nematodes up to species level. Drawing and measurements of nematodes, preparation of compendia and keys. Identification of species/races of root-knot and cyst nematodes using PAGE.

Suggested Readings
NEMA 602  CURRENT TOPICS IN NEMATODE DISEASE DEVELOPMENT  3+0  SEM - I

Objective
To update knowledge on the recent research trends in the field of plant nematode relationships at genetic and molecular level.

Theory
UNIT-I: Mechanisms of pathogenesis, cytological and biochemical changes induced by nematode feeding.
UNIT-II: Plant defense systems, role of phytoalexins etc. against major plant parasitic nematodes.
UNIT-III: Genetic basis of plant resistance to nematodes and identification of resistance genes against economically important nematodes.
UNIT-IV: Application of biotechnological methods in the development of nematode resistant crop cultivars; resistance markers; incorporation of resistance by conventional breeding and transgenic approaches.
UNIT-V: Influence of microorganisms on plant nematode interactions.

Suggested Readings

NEMA 603  ADVANCES IN NEMATODE MANAGEMENT  2+1  SEM - II

Objective
To keep abreast with latest developments and trends in nematode management.

Theory
UNIT-I: Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- predacious and parasitic fungi; nematotoxic fungal culture filtrates.
UNIT-II: Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- parasitic and nematode antagonistic bacteria; predacious mites and predacious nematodes.
UNIT-IV: Phytoalexins, allelochemicals, phytotherapeutic substances, novel nematicides, deployment of resistant varieties and non-host crops in nematode suppressive cropping systems, emergence of resistance breaking biotypes, recent regulatory provisions and methods, quarantine and disinfection.
UNIT-V: Nematode management modules for integrated pest and disease management in cropping systems. Nematode management options and approaches for organic farming and precision farming. Application of GIS and GPS technology for surveillance and management.

Practical
Green-house experiments on the efficacy of fungal and bacterial bio-control agents, botanicals.

Suggested Readings
NEMA 604        PHYSIOLOGICAL AND MOLECULAR       2+1        SEM - II
NEMATOLOGY

Objective
Appraisal on the application of modern biotechnological tools in Nematology.

Theory
UNIT-I: Cell biology- Structural and functional aspects; genetics and evolution in plant parasitism in nematodes.
UNIT-II: Caenorhabditis elegans- a model system for gerontology, cytogenetics, physiology, nutritional, toxicological and pharmacological studies; Heterodera glycines as a model for biology, proteomic and genomic studies.
UNIT-III: Chemoreception, neurobiology, and biochemical basis of communication in nematodes, molecular basis of host recognition.
UNIT-IV: Biochemical, genetic and molecular basis of plant nematode interaction; histopathological, cellular and molecular changes in host feeding cells, resistance genes and RNAi technology.
UNIT-V: Biochemical and molecular basis of survival strategies in nematodes, molecular mechanism of host resistance against plant parasitic nematodes, molecular and novel approaches for nematode management.

Practical
Isolation and quantification of proteins from nematode juveniles and eggs; molecular weight determination of nematode protein; β-esterase polymorphism in root-knot nematode; nematode DNA isolation from juveniles and eggs; RFLP of nematode DNA; nematode DNA amplification using PCR for nematode identification, RNAi technology.

Suggested Readings

NEMA 605/       PLANT BIOSECURITY AND BIOSAFETY       2+0        SEM - 1
PL PATH 606/ (To be taught jointly by Entomology and Plant Pathology)
ENTO 613

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

Theory
UNIT-I: History of biosecurity, concept of biosecurity, components of biosecurity, Quarantine, Invasive Alien Species, biowarfare, emerging/resurgence of pests and diseases.
UNIT-II: National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Suggested Readings
www.fao.org/docrep/010/a1140e/a1140e00.htm
Laboratory Biosecurity Guidance.
http://www.americanprogress.org/kt/biosecurity_a_comprehensive_action_plan.pdf
Biosecurity New Zealand. www.biosecurity.govt.nz
DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001. Transgenic Crops
and Biosafety Concerns. NBPGP, New Delhi.
NEMATOLOGY

List of Journals

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

e-Resources

- http://www.nematologists.org/ (The Society of Nematologists)
- http://nematology.ucdavis.edu/ (Deptt. of Nematology, Univ. of California, Davis)
- http://www.ifns.org/ (International Federation of Nematology Societies)
- http://www.inaav.bacnr.it/nemmed.html (Nematologia Mediterranea)
- http://nematode.unl.edu/Nemajob.htm (Nematology Employment Bulletin Board)
- http://nematode.unl.edu/ (University of Nebraska - Lincoln Nematology)
- http://nematode.unl.edu/wormsite.htm (Links to Other Nematology Resources)
- http://nematode.unl.edu/SON/jon.htm (Journal of Nematology)
- http://flnem.ifas.ufl.edu/HISTORY/nem_history.htm (Nematology history)
- http://www.nematology.ugent.be/ (Nematology Unit, Ghent University)
- http://www.entm.purdue.edu/nematology/ (The Purdue Nematology Lab.)
- http://www.bspp.org.uk/ppigb/nematology.htm#a-z (Links to Nematology labs)
- http://www.nem.wur.nl/UK/ (Laboratory of Nematology, Wageningen Univ.)
- http://onta.ifas.ufl.edu/ (The Organization of Nematologists of Tropical America)
- http://nematology.umd.edu/nematology.html (Plant Nematology Laboratory, Maryland)
- http://www.biology.leeds.ac.uk/nem/ (Plant Nematology Lab., University of Leeds)
- http://www.plantpath.iastate.edu/dept/labs/tylka/ (Iowa State University, Nematology Lab)
- http://soilplantlab.missouri.edu/nematode/ (Plant Nematology Laboratory, Missouri)
- http://www.eumaine.ugent.be/ (European Master of Science in Nematology)

Suggested Broad Topics for Master’s and Doctoral Research

- Identification of key nematode pests emerging in regional agro-ecosystems
- Development of molecular diagnostic tools of phytonematodes
- Nematode problems of peri-urban and protected agriculture systems, and their management
- Role of nematodes in organic matter recycling
- Modelling nematode populations for disease forecasting and predicting yield losses
- Nematodes as indicators of environmental pollution
- Identification of cost effective nematode-suppressive cropping systems for specific agro-ecosystems
- Isolation, identification and characterization of phytochemicals for nematoxicy
- Disinfection of nematode-infected planting material through eco-friendly sanitary methods
- Characterization of molecular markers and genes governing resistance to key nematode pests
- Management of nematodes with antagonistic bacteria
- Bionomics of potential bio-control agents and their field efficacy
- Devising non-chemical methods of nematode management in mushroom cultivation
- Development of nematode management modules for IPM systems
- Field efficacy and formulation of entomopathogenic nematodes against foliar and soil-borne insect pests of crops
- Study of disease complex involving nematodes and other plant pathogens.
- Nematode suppressive rhizospheric microorganisms.
## PLAN PATHOLOGY

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**SERVICE COURSE**

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*Compulsory for Master’s programme; ** Compulsory for Doctoral programme
One course of Biochemistry or G&PB of 3 credits is compulsory as Minor/Supporting
To be taught by: 1 Plant Pathology; 2 Entomology and Plant Pathology; 3 Entomology
PLANT PATHOLOGY

Course Contents

PL PATH 501  MYCOLOGY  2+1  SEM - I

Objective
To study the nomenclature, classification and characters of fungi.

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

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

Suggested Readings

PL PATH 502  PLANT VIROLOGY  2+1  SEM - II

Objective
To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory
UNIT-II: Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship.
UNIT-IV: Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics.
UNIT-V: Mycoviruses, phytoplasm aro and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultramicrotome.

Practical
Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratomy, PCR.

Suggested Readings
PL PATH 503     PLANT BACTERIOLOGY     2+1     SEM - II

Objective
To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional
requirements, survival and dissemination.

Theory
UNIT-I: History and introduction to phytopathogenic procarya, viz., bacteria, MLOs,
spiroplasmas and other fastidious procarya, importance of phytopathogenic bacteria.
UNIT-II: Evolution, classification and nomenclature of phytopathogenic procarya and
important diseases caused by them.
UNIT-III: Growth, nutrition requirements, reproduction, preservation of bacterial cultures
and variability among phytopathogenic procarya.
UNIT-IV: General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.
UNIT-V: Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.
UNIT-VI: Survival and dissemination of phytopathogenic bacteria.

Practical
Isolation, purification, identification and host inoculation of phytopathogenic bacteria,
staining methods, biochemical and serological characterization, isolation of plasmid and
use of antibacterial chemicals/antibiotics.

Suggested Readings
Management. Angkor Publ.

PL PATH 504     PRINCIPLES OF PLANT PATHOLOGY     3+0     SEM - I

Objective
To introduce the subject of Plant Pathology, its concepts and principles.

Theory
UNIT-I: Importance, definitions and concepts of plant diseases, history and growth of
plant pathology, biotic and abiotic causes of plant diseases.
UNIT-II: Growth, reproduction, survival and dispersal of important plant pathogens, role
of environment and host nutrition on disease development.
UNIT-III: Host parasite interaction, recognition concept and infection, symptomatology,
disease development- role of enzymes, toxins, growth regulators; defense strategies-
oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors, altered plant metabolism
as affected by plant pathogens.
UNIT-IV: Genetics of resistance; R genes; mechanism of genetic variation in pathogens;
molecular basis for resistance; marker-assisted selection; genetic engineering for disease
resistance.
UNIT-V: Disease management strategies.

Suggested Readings
Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and
Evolving Biotechnology. Oxford & IBH.

PL PATH 505     DETECTION AND DIAGNOSIS OF PLANT DISEASES

Objective
To impart training on various methods/techniques/instruments used in the study of plant
diseases/pathogens.
Practical
UNIT-I: Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens.
UNIT-II: Preservation of plant pathogens and disease specimens, use of haemocytometer, stage and ocular micrometer, centrifuge, pH meter, camera lucida.
UNIT-III: Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of references.

Suggested Readings

PL PATH 506 PRINCIPLES OF PLANT DISEASE MANAGEMENT 2+1 SEM - I

Objective
To acquaint with different strategies for management of plant diseases.

Theory
UNIT-I: Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases, disease resistance and molecular approach for disease management.
UNIT-II: Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures.
UNIT-III: History of fungicides, bactericides, antibiotics, concepts of pathogen immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

Practical
In vitro and in vivo evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

Suggested Readings
Hewitt HG. 1998. Fungicides in Crop Protection. CABI.

PL PATH 507 DISEASES OF FIELD AND MEDICINAL CROPS 2+1 SEM - I

Objective
To educate about the nature, prevalence, etiology, factors affecting disease development and control measures of field and medicinal crop diseases.

Theory
UNIT-I: Diseases of Cereal crops- wheat, barley, rice, pearl millet, sorghum and maize.
UNIT-II: Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean.
UNIT-IV: Diseases of Cash crops- cotton, sugarcane.
UNIT-V: Diseases of Fodder crops- berseem, oats, guar, lucerne, cowpea.
UNIT-VI: Medicinal crops- plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, Aloe vera.

Practical
Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

PL PATH 508 DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS 2+1 SEM - I

Objective
To acquaint with diseases of fruits, plantation, ornamental plants and their management.

Theory
UNIT-I: Introduction, symptoms and etiology of different fruit diseases, factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm and management of the fruits diseases.
UNIT-II: Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management.
UNIT-III: Symptoms and life cycle of pathogen, factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, orchids, marigold, chrysanthemum and their management.

Practical
Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops, collection and dry preservation of diseased specimens of important crops.

Suggested Readings

PL PATH 509 DISEASES OF VEGETABLE AND SPICE CROPS 2+1 SEM - II

Objective
To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices and their management.

Theory
UNIT-I: Nature, prevalence, factors affecting disease development of bulb, leafy vegetable, crucifers, cucurbits and solanaceous vegetables, diseases of protected cultivation.
UNIT-II: Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceous vegetable crops.
UNIT-III: Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger.
**Practical**

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

**Suggested Readings**


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**PL PATH 510/ SST 510**  
**SEED PATHOLOGY**  
2+1  
SEM - I

**Objective**

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/losses and management.

**Theory**

UNIT-I: History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO, morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

UNIT-II: Recent advances in the establishment and subsequent cause of disease development in seed and seedling, localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

UNIT-III: Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens, epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

UNIT-IV: Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganisms.

**Practical**

Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

**Suggested Readings**


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**PL PATH 511**  
**CHEMICALS IN PLANT DISEASE MANAGEMENT**  
2+1  
SEM - II

**Objective**

To impart knowledge on the concepts, principles and judicious use of chemicals in plant disease management.

**Theory**

UNIT-I: History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals.

UNIT-II: Classification of chemicals used in plant disease control and their characteristics.

UNIT-III: Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals.

UNIT-IV: Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

UNIT-V: Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factors affecting fungicides.
UNIT-VI: General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical
Acquaintance with formulation of different fungicides and plant protection appliances, formulation of fungicides, bactericides and nematicides; in vitro evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogens; methods of application of chemicals.

Suggested Readings

PL PATH 512  ECOLOGY OF SOIL-BORNE PLANT PATHOGENS  2+1  SEM - I

Objective
To provide knowledge on soil-plant disease relationship.

Theory
UNIT-I: Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi, types of biocontrol agents.
UNIT-II: Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

Practical
Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms, isolation and identification of different biocontrol agents.

Suggested Readings
Cook RJ & Baker KF. 1983. The Nature and Practice of Biological Control of Plant Pathogens. APS.
Hillocks RJ & Waller JM. 1997. Soil-borne Diseases of Tropical Crops. CABI.

PL PATH 513/ NEMA 513  DISEASE RESISTANCE IN PLANTS  2+0  SEM - II

Objective
To acquaint with disease resistance mechanisms in plants.

Theory
UNIT-I: Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.
UNIT-II: Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.
UNIT-III: Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.
UNIT-IV: Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes, strategies for gene deployment.

Suggested Readings
Objective
To teach the students about the different groups of insects that are vectors of plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory
UNIT-I: History of developments in the area of insects as vectors of plant pathogens, important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors, efficiency of transmission.
UNIT-II: Transmission of plant viruses and fungal pathogens, relation between viruses and their vectors.
UNIT-III: Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.
UNIT-IV: Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.
UNIT-V: Transmission of plant viruses by psyllids, beetles and mites, epidemiology and management of insect transmitted diseases through vector management.

Practical
Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

Suggested Readings

Objective
To study principles and application of ecofriendly and sustainable management strategies of plant diseases.

Theory
UNIT-I: Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.
UNIT-II: Types of biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiotics, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.
UNIT-III: Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases, compatibility of different bioagents.
UNIT-IV: Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market, quality control system of biocontrol agents.
Practical
Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen in vitro and in vivo conditions, study of cfu/g.

Suggested Readings

PL PATH 516 INTEGRATED PLANT DISEASE MANAGEMENT 2+1 SEM - II
Objective
To emphasize the importance and need of IDM in the management of diseases of important crops.

Theory
UNIT-I: Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.
UNIT-II: Development of IDM- basic principles, biological, chemical and cultural disease management.
UNIT-III: IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed mustard, pearl millet, kharif pulses, vegetable crops and fruit crops.

Practical
Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in certain crops as project work.

Suggested Readings

PL PATH 517 MUSHROOM PRODUCTION TECHNOLOGY 2+1 SEM - II
Objective
To develop mushroom cultivation skills for entrepreneurial activity, historical development of mushroom cultivation and present status of mushroom industry in India.

Theory
UNIT-I: Historical development of mushroom cultivation and present status, taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.
UNIT-II: Life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.
UNIT-III: Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.
UNIT-IV: Facilities for setting up mushroom farm for seasonal and environmentally control cultivation, requirement and maintenance of temperature, relative humidity, CO2, ventilation in cropping rooms, cultivation technology of Agaricus bisporus, Pleurotus sp., Calocybe indica, Lentinus edodes and Ganoderma lucidum.
UNIT-V: Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practical
Preparation of spawn, compost, spawning, casing, harvesting and postharvest handling of edible mushroom; identification of various pathogens, competitors of various mushroom.

Suggested Readings

PL PATH 518  EPIDEMIOLOGY AND FORECASTING  2+1  SEM - II  OF PLANT DISEASES

Objective
To acquaint with the principles of epidemiology and its application in disease forecasting.

Theory
UNIT-I: Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis.
UNIT-II: Common and natural logarithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens.
UNIT-III: Survey, surveillance and vigilance, crop loss assessment and models.
UNIT-IV: Principles and pre-requisites of forecasting systems and factors affecting various components of forecasting, some early forecasting procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical
Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, computerized data analysis, function fitting, model preparation and validation.

Suggested Readings

PL PATH 519  POST HARVEST DISEASES  2+1  SEM - I

Objective
To acquaint with post harvest diseases of agricultural produce and their ecofriendly management.

Theory
UNIT-I: Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as preharvest and post-harvest, merits and demerits of biological control/phytoextracts in controlling post-harvest diseases.
UNIT-II: Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.
UNIT-III: Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists, isolation, characterization and maintenance of pathogens, role of different storage conditions.

UNIT-IV: Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarius for each product and commodity.

Practical
Isolation characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens in vivo and in vitro conditions, comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested Readings

PL PATH 520/ PLANT QUARANTINE 2+0 SEM - II
ENT 520/
NEMA 514 (To be taught by Entomology)

Objective
To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory
UNIT-I: Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.
UNIT-III: Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfection/salvaging of infected material.
UNIT-IV: WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

PL PATH 601 ADVANCED MYCOLOGY 2+1 SEM - II

Objective
To acquaint with the latest advances in Mycology.

Theory
UNIT-I: General introduction, historical development and advances in mycology.
UNIT-II: Recent taxonomic criteria, morphological criteria for classification, serological, chemical (chemotaxonomy), molecular and numerical (Computer based assessment) taxonomy.
UNIT-III: 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.
UNIT-IV: Population biology, pathogenic variability/vegetative compatibility.
UNIT-V: Heterokaryosis and parasexual cycle, sex hormones in fungi, pleomorphism and speciation in fungi, mechanism of nuclear inheritance, mechanism of extra-nuclear inheritance, biodegradation.

Practical
Study of conidiogenesis- phialides, porosores, arthospores, study of fruit bodies in Ascomycotina, identification of fungi up to species level, study of hyphal anastomosis, morphology of representative plant pathogenic genera from different groups of fungi.

Suggested Readings

PL PATH 602 ADVANCED VIROLOGY 2+1 SEM - I

Objective
To educate about the advanced techniques and new developments in the field of Plant Virology.

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

Suggested Readings
PL PATH 603  ADVANCED BACTERIOLOGY  2+1  SEM - II

Objective
To provide knowledge about the latest advances in phytobacteriology.

Theory
UNIT-I: Current approaches for the characterization and identification of phytopathogenic bacteria, ultrastructures and biology of bacteria.
UNIT-II: Current trends in taxonomy of phytopathogenic procaryota.
UNIT-III: Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development, mechanism of wilt (Ralstonia solanacearum) development, mechanism of soft rot (Erwinia spp.) development, mechanism of Crown gall formation (Agrobacterium tumifaciens).
UNIT-IV: Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, Effector protein.
UNIT-V: Molecular variability among phytopathogenic procaryota and possible host defense mechanism(s), genetic engineering for management of bacterial plant pathogen-gene silencing, RNAi technology.
UNIT-VI: Epidemiology in relation to bacterial plant pathogens, development of diagnostic kit.
UNIT-VII: Beneficial procaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management, endosymbionts for host defence.

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

Suggested Readings

PL PATH 604  MOLECULAR BASIS OF HOST-PATHOGEN INTERACTIONS  2+1  SEM - II

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

Theory
UNIT-I: Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.
UNIT-II: Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction.
UNIT-IV: 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.
Practical

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

Suggested Readings


PL PATH 605/ PLANT BIOSECURITY AND BIOSAFETY 2+0 SEM - I
ENT 613/ (To be taught jointly by Entomology and Plant Pathology)
NEMA 605

Objective

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

Theory

UNIT-I: History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.
UNIT-II: National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

Suggested Readings

Laboratory Biosecurity Guidance.
http://www.who.int/csr/resources/publications/biosafety/
WHO_CDS_EPR_2006.pdf
http://www.americanprogress.org/kf/biosecurity_a_comprehensive_action_plan.pdf
Biosecurity New Zealand. www.biosecurity.govt.nz
DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
PLANT PATHOLOGY

List of Journals

- *Annual Review of Phytopathology* ã Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* - Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* - Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* - National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research* - Indian Society of Mycology, Kolkata.
- *Indian Journal of Virology* - Indian Virological Society, New Delhi
- *Indian Phytopathology* - Indian Phytopathological Society, New Delhi
- *Journal of Mycology and Plant Pathology* - Society of Mycology and Plant Pathology, Udaipur
- *Journal of Phytopathology* - Blackwell Verlag, Berlin
- *Mycologia* - New York Botanical Garden, Pennsylvania
- *Mycological Research* - Cambridge University Press, London
- *Phytopathology* - American Phytopathological Society, USA
- *Plant Disease* - The American Phytopathological Society, USA
- *Plant Disease Research* ã Indian Society of Plant Pathologists, Ludhiana
- *Plant Pathology* - British Society for Plant Pathology, Blackwell Publ.

e-Resources

- www.shopapspress.org
- www.apsjournals.apsnet.org
- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

Suggested Broad Topics for Master’s and Doctoral Research

- Pathogenesis and characterization of plant pathogens
- Survey and surveillance
- Induction of resistance using biotic and abiotic elicitors
- Variability in plant pathogens
- Plant-Virus-Vector relationships
- Genome organization of plant pathogens
- Dynamics of plant pathogen propagules and their biology
- Molecular tools in disease diagnosis
- Molecular mechanisms of pathogenesis in crops and seeds
- Rhizosphere in pathogenesis of seed-borne plant pathogens
- Transgenic resistance
- Development of disease prediction models in disease forecasting
- Integrated Disease Management
- Molecular Taxonomy of different plant pathogens
- Development of Rapid Diagnostic methods
- Development and Formulation of Improved Biocontrol Agent
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**SERVICE COURSE**

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*Compulsory for Master’s programme; **Compulsory for Doctoral programme

To be taught by: 1 Vegetable Science; 2 Fruit Science 3 Processing & Food Engineering; 4 Botany & Plant Physiology; 5 Plant Pathology; 6 Entomology; 7 Agricultural Economics; 8 Genetics & Plant Breeding
SEED SCIENCE AND TECHNOLOGY

Course Contents

SST 501  FLORAL BIOLOGY, SEED DEVELOPMENT  1+1  SEM - I
AND MATURATION

Objective
To refresh the basic knowledge of seed development and structures and apprise students with its relevance to production of quality seed.

Theory
UNIT-I: Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and megasporeogenesis; gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology.
UNIT-II: Fertilization - embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.
UNIT-III: Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.
UNIT-IV: Apomixis - identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practical
Study of floral biology of monocots and dicots; microsporogenesis and megasporeogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

Suggested Readings

SST 502  PRINCIPLES OF SEED PRODUCTION  2+0  SEM - I

Objective
To introduce the basic principles of quality seed production.

Theory
UNIT-I: Introduction : Seed as basic input in agriculture; seed development in cultivated plants; seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops.
UNIT-II: Mode of pollination and reproduction in crop plants and their modification in relation to hybrid seed production. Principles of hybrid seed production, isolation distance, synchronization of flowering, roguing etc. male sterility and incompatibility system in hybrid seed production, role of pollinators and their management.
UNIT-III: Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production - agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and
Certified seed criteria involved; life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops.

UNIT-IV: Hybrid Seed - Methods of development of hybrids; use of male sterility and self-incompatibility and CHA in hybrid seed production; one, two and three line system; maintenance of parental lines of hybrids; planning and management of hybrid seed production technology of major field crops and vegetables.

UNIT-V: Planning of seed production for different classes of seeds for self and cross-pollinated crops, Seed quality control system and organization, seed village concept; Seed production agencies, seed industry and custom seed production in India.

Suggested Readings

Tunwar NS & Singh SV. 1985. Handbook of Cultivars. CSCB, GOI.

SST 503  SEED PRODUCTION IN FIELD CROPS  2+1  SEM - I

Objective
To impart a comprehensive knowledge of seed production in field crops with adequate practical training.

Theory

UNIT-I: Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.
UNIT-II: Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc; methods and techniques of quality seed production in cross-pollinated cereals and millets.
UNIT-III: Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green garm, black garm, field beans, peas etc.).
UNIT-IV: Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).
UNIT-V: Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

Practical
Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, hand emasculation and pollination in Cotton, detasseling in Corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc.

Suggested Readings

SEED PRODUCTION IN VEGETABLES

**Objective**
To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training.

**Theory**
UNIT-I: Introduction; modes of propagation in vegetables. Seed morphology and development in vegetable seeds. Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT-II: Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.

UNIT-III: Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

UNIT-IV: Share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

**Practical**
Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production in vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; exercises on emasculation and pollination; seed extraction methods and their effect on quality seed of vegetables; seed production technology of varieties and hybrids in vegetables.

**Suggested Readings**

SEED PRODUCTION IN FLOWERS,

**Objective**
To impart comprehensive knowledge of seed production in horticultural crops with adequate practical training.
Theory

UNIT-I: Introduction: modes of propagation in fruits, flower and plantation crops. Floral biology of these plant species; classification of medicinal and horticultural crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT-II: Flowers and Medicinal Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important flower species i.e. marigolds, petunias, dahlia, roses, gladiolus, tulips, chrysanthemum etc; development of hybrids and their seed production technology of flower plants. Seed production technology of annual medicinal plants viz. isabgol, ashawagandha etc.

UNIT-III: Fruit and Plantation Crops: role of seed in perennial plant species; classification based on reproduction and pollination behavior; polyembryony and its significance; nursery requirement, planning and management; clonal propagation and multiplication in tropical, sub-tropical and temperate fruits and plantation crops; seed orchards; seed collection, extraction and processing.

UNIT-IV: IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of flowers, fruits, medicinal and plantation crops; determination of planting ratios for hybrid seed production in flowers; exercises on emasculation and pollination; seed extraction methods and their effect on seed quality of fruit; seed production technology of varieties and hybrids; seed collection and extraction in fruit and plantation crops.

Suggested Readings

ICAR. Hand Book of Horticulture. ICAR.

SST 506 SEED LEGISLATION AND CERTIFICATION 2+1 SEM - II

Objective

To apprise students with the legislative provisions and processes and the mechanisms of seed quality control.

Theory

UNIT-I: Historical development of Seed Industry in India; Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control- concept and objectives; Central Seed Certification Board (CSCB).

UNIT-II: Regulatory mechanisms of seed quality control- organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control; the Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004 etc. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India.
UNIT-III: Seed Certification- history, concept and objectives of seed certification; seed certification agency/organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (I.M.S.C.S.)- general and specific crop standards including GM varieties, field and seed standards; planning and management of seed certification programmes- eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc.

UNIT-IV: Field Inspection- principles, phases and procedures; reporting and evaluation of observations; pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes.

UNIT-V: Introduction to WTO and IPRs; Plant Variety Protection and its significance; UPOV and its role; DUS testing- principles and applications; essential features of PPV & FR Act, 2001 and related Acts.

Practical
General procedure of seed certification ; identification of weed and other crop seeds as per specific crops; field inspection at different stages of a crop and observations recorded on contaminants and reporting of results; inspection and sampling at harvesting/threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.

Suggested Readings

SST 507/ PFE 514
SEED DRYING, PROCESSING AND STORAGE 2+1 SEM - II
(To be taught by Processing and Food Engineering)

Objective
To acquaint the students with drying and processing of seeds, operation and maintenance of different seed processing machinery and dryers .

Theory
UNIT-I: Principles and importance of seed processing, preparation of seeds before processing, machines used to prepare seed for processing (Delinters, extractors, debearder, sacrificer etc.)
UNIT-II: Operation maintenance of different seed processing machinery such as air screen cleaner, indented cylinder, dise separator, gravity separator, pneumatic separator, surface texture equipment, shape, size, colour sorter, magnetic separator, electrostatic separator, seed conveying, different types of conveyers, seed treating, and treaters.
UNIT-III: Seed drying - principles and methods, E.M.C. Theory of drying, calculation of drying time, different types of heated air dryers, importance of scientific seed storage, types of storage structures, methods of maintaining safe seed moisture, thumb rule and its relevance, management and operation/ cleanliness of seed store, design features of medium and long term seed storage structures.
UNIT-IV: Seed packaging, principles, practices, materials, weighing and bagging machines, their operation and maintenance, seed quality maintenance during processing. Plant design and lay out, safety considerations in plant design.

Practical
Operation and performance evaluation of various seed processing equipments such as pre cleaner, scalpers, air screen cleaner, indented cylinder, gravity separator, pneumatic separator, colour sorter and other equipments, seed treater, conveyors and elevators, bag closers, different types of dryers, design and layout of seed processing plant and its
Suggested Readings
Gregg et al. 1970. Seed Processing. NSC.

SST 508 SEED QUALITY TESTING 2+1 SEM - II

Objective
To provide a comprehensive knowledge on all aspects of seed quality evaluation and their relevance to crop performance.

Theory
UNIT-I: Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA and its role in seed testing.
UNIT-II: Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory.
UNIT-III: Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable varieties (ODV); determination of test weight and application of heterogeneity test.
UNIT-IV: Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results.
UNIT-V: Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy.
UNIT-VI: Viability and Vigour Testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.
UNIT-VII: Genetic purity testing: objective and criteria for genetic purity testing; types of tests; laboratory, Growth Chamber and field testing based on seed, seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests.
UNIT-VIII: Seed health Testing: field and seed standards; designated diseases, objectionable weeds - significance of seed borne diseases vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes.
UNIT-IX: Testing of GM seeds and trait purity, load of detection (LOD).
UNIT X: Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practical
Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods, requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agri-horticultural crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour.
tests applicable in various crops; species & cultivar identification; genetic purity testing by
chemical, biochemical and molecular methods; seed health testing for designated diseases,
blotter methods, agar method and embryo count methods; testing coated/pelleted seeds.

Suggested Readings
South Asian Publ.
Tunwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central
Seed Certification Board, Ministry of Agriculture, New Delhi.

SST 509/ PP 511
SEED PHYSIOLOGY 1+1 SEM - I
(To be taught by Botany & Plant Physiology)

Objective
To provide an insight into physiological processes governing seed quality and its survival.

Theory
UNIT-I: Physiology of seed development and maturation; chemical composition,
synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal
regulation of seed development.
UNIT-II: Seed germination; factors affecting germination; role of embryonic axis; growth
hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored
reserves in seeds, mobilization and inter-conversion pathways. Seed dormancy- types,
significance, mechanism, endogenous and exogenous factors regulating dormancy, role of
phytochrome and PGR, genetic control of dormancy.
UNIT-III: Seed viability and longevity, pre and post-harvest factors affecting seed
viability ; seed ageing ; physiology of seed deterioration ; lipid peroxidation and other
viability theories; means to prolong seed viability; mechanism of desiccation sensitivity
and recalcitrance with respect to seed longevity.
UNIT-IV: Seed vigour and its concept, vigour test methods, factors affecting seed vigour,
physiological basis of seed vigour in relation to crop performance and yield. Seed
invigoration and its physiological and molecular control.

Practical
Proximate analysis of chemical composition of seed; methods of testing viability; kinetics
of seed imbibition and solute leakage; seed germination and dormancy breaking methods;
seed invigoration and priming treatments; accelerated ageing and controlled deterioration
tests; enzymatic activities and respiration during germination and effect of accelerated
ageing; vigour testing methods etc.

Suggested Readings
Kigel J & Galili G. (Eds.). *Seed Development and Germination*. Marcel Dekker.

SST 510/  PL PATH 510  2+1  SEM - I
(To be taught by Plant Pathology)

Objective
To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/losses and management.

Theory
UNIT-I: History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.
UNIT-II: Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.
UNIT-III: Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.
UNIT-IV: Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical
Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

Suggested Readings

SST 511  SEED ENTOMOLOGY  2+1  SEM - II
(To be taught by Entomology)

Objective
To apprise about the role of insects in seed production and their effect on seed quality during storage.

Theory
UNIT-I: Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.
UNIT-IV: Storage insect pests infecting seeds, their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation.
UNIT-V: Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures I domestic and commercial.

Practical
Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis-a-vis loss of seed quality. Safe handling and use of fumigants and insecticides; safety measures in fumigating and disinfecting, exposure period, aeration etc. the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application.
Suggested Readings
Agarwal NA & Girish GK. 1977. An Introduction to Action Programme to Regress on Farm Storage Losses in India. FAO/NORAD Seminar on Farm Storage Grain in India, Nov. 29-Dec. 8, 1977.

SST 512 SEED PRODUCTION IN FORAGE, PASTURE AND GREEN MANURE CROPS 2+1 SEM - II

Objective
To apprise about the basic requirements and methods of quality seed production in forage, pasture and green manure crops.

Theory
UNIT-I: Important pasture and forage legume crops in India; seed requirement and production; classification of forage, pastures and green manure crops; pollination behavior.
UNIT-II: Factors influencing seed production; maintenance of varietal purity, generation systems of seed multiplication in self pollinated crops; seed production in apomictic grasses.
UNIT-III: Methods and techniques of seed production in important grasses, pastures, legumes and green manure crops; apomictic seed.
UNIT-IV: Selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting, pelleting, fertilizer and manure requirement, isolation distance, weed control, pollination and seed setting, seed shattering, seed maturity and stage of harvest, seed collection, economics of seed production of important fodder crops.
UNIT-V: Seed processing, seed treatment, seed storage, seed viability of these crops.

Practical
Study of flower structure, seed collection and identification, characteristics of forage, pastures and green manure crops; maturity indices for harvest, seed testing- sampling, purity, moisture, germination and dormancy, seed treatments.

Suggested Readings
Froma J. 1997. Temperate Forage Legumes. CABI.
Gutteridge RG. 1997. Forage Tree Legumes in Tropical Agriculture. CABI.

SST 513 SEED STORAGE AND DETERIORATION 1+1 SEM - II

Objective
To provide understanding of the mechanism of seed ageing during storage, factors affecting it and its control.

Theory
UNIT-I: 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.
UNIT-II: Factors affecting seed storability- biotic and abiotic and pre- and post-harvest 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.
UNIT-III: 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.

UNIT-IV: 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.

Suggested Readings
McDonald MB & Roos EE. (Eds.). 1986. Physiology of Seed Deterioration. Paper No. 11, Crop Science Society of America, USA.

SST 514/ AG ECON 510
(SEED MARKETING AND MANAGEMENT 2+1 SEM - II)
(To be taught by Agricultural Economics)
Objective
To train the students regarding economic concepts of seed marketing in India and role of Government in development of efficient seed marketing system.

Theory
UNIT-I: Basic concepts of agricultural marketing, seed marketing, importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector.
UNIT-II: Demand and supply of seed, cost of production and returns and factors determining seed needs, pricing policies, seed pricing and price policies, seed processing and packing/packaging.
UNIT-III: Purpose and approaches to seed marketing; Seed marketing mix, sales promotion, distribution channels, marketing costs and margins; Market research information and segmentation.
UNIT-IV: Policy environment for sustainable growth of seed sector in India. Salient features of proposed seed act and national seed policy, role of government in efficient seed marketing, quality control and assurance. WTO and seed industry in India.

Practical
Estimation of cost of seed production, marketing costs and margins of seeds of different crops. Estimation of seed demand and supply, seed forecasting techniques, marketing plan.

Suggested Readings
SST 515  
**EMERGING TRENDS IN SEED QUALITY ENHANCEMENT**

**Objective**
To update knowledge on seed quality enhancement technologies and their application.

**Theory**

UNIT-I: Concept and significance of seed quality enhancement; physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology and factors affecting seed enhancement treatments.

UNIT-II: Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pregermination, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.

UNIT-III: Synthetic seeds I Aim and scope for synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryo-preservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

**Practical**
Seed treatments I methods and techniques, equipments required for seed treatment, film coating; seed invigoration/priming - hydration and dehydration, PEG priming, solid matrix priming, bio priming, effects of priming; methods for hydrogel encapsulation of artificial endosperm, hydrophobic coating etc.; protocols for production of synthetic seeds, Visit to leading Seed Companies to study the seed treatment processes.

**Suggested Readings**

SST 516/ GP 517  
**DATABASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR**

**Objective**
To train the students in germplasm data base management using modern tools and softwares.

**Theory**

UNIT-I: Statistical techniques in management of germplasm, core identification, estimation of sample size during plant explorations, impact of sampling on population structure; sequential sampling for viability estimation, introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and nomograms, estimation of sample size for storage and viability testing.

UNIT-II: Germplasm documentation; basics of computer and operating systems, database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.

UNIT-III: Germplasm management system: global scenario, genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; predictive methods for identification of useful germplasm; characterization of germplasm and evaluation procedures including specific traits, Gene markers and their use in PGR management, germplasm enhancement, prebreeding and utilizing wild species in crop improvement.

UNIT-IV: Management and utilization of germplasm collections; concept of core collection, molecular markers and their use in characterization, evaluation and utilization of genetic resources; pre-breeding/ genetic enhancement, utilizing wild species for crop
improvement; harmonizing agro-biodiversity and agricultural development crop diversification; participatory plant breeding.

Practical
Basics of computer and operating systems- identification of useful germplasm; evaluation of crop germplasm, Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing. Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of Characterization of germplasm; Molecular markers and their use in characterization.

Suggested Readings

SST 601 HYBRID SEED PRODUCTION 1+1 SEM - II
Objective
To provide a comprehensive knowledge and practical exposure to hybrid seed production in field crops and vegetables.

Theory
UNIT-I: Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.
UNIT-II: Pre-requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.
UNIT-III: 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.
UNIT-IV: 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.

Suggested Readings

SST 602/ IN SITU AND EX SITU CONSERVATION OF 2+1 SEM - II
GP 610 GERMPLASM
(To be taught by Genetics and Plant Breeding)
Objective
To impart knowledge on the methods of germplasm conservation.

Theory
UNIT-I: Concept of natural reserves and natural gene banks, In situ conservation of wild species in natural reserves: in situ conservation components, factors influencing conservation value, national plan for in situ conservation; in situ conservation of agro-biodiversity off-farm; scientific basis of in situ conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of in situ
conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.


UNIT-III: *In vitro* storage, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in vitro* gene bank.

UNIT-IV: Cryopreservation- procedure for handling seeds of orthodox and 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 aheads.

Practical

*In situ* conservation of wild species ½ 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 NBPR/NGAGR - study using fruit crops and other horticultural crops.

Suggested Readings


**SST 603 TESTING FOR GENUINENESS AND PURITY OF CULTIVARS**

**Objective**

To provide hands-on training on various field and laboratory methods of testing cultivar purity.

**Theory**

UNIT-I: 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.

UNIT-II: 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.

UNIT-III: DNA fingerprinting (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties.

UNIT-IV: Use of computer-based machine vision (MVT) for varietal identification and purity testing.

**Practical**

Chemical and biochemical tests for species and cultivar purity: 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.
Suggested Readings

SST 604 DUS TESTING FOR PLANT VARIETY PROTECTION 2+1 SEM - I

Objective
To provide a comprehensive understanding of DUS testing, its conduct and significance to PVP.

Theory
UNIT-I: 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.
UNIT-II: 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.
UNIT-III: 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.

Suggested Readings

SST 605 ADVANCES IN SEED SCIENCE RESEARCH 1+0 SEM - II

Objective
To provide knowledge on the advances in various aspects of seed science & their application in seed technology.

Theory
UNIT-I: 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.
UNIT-II: 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).
UNIT-III: Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.
UNIT-IV: Seed production of self incompatible and apomictic plant species; recent developments in seed laws, policies and seed certification system in India and its comparison with OECD seed certification schemes; IPR systems and PVP internationally.
Suggested Readings

SEED SCIENCE AND TECHNOLOGY

List of Journals

- Acta Horticultrae
- Crop Science
- Hort. Science
- Indian Journal of Agricultural Science.
- ISST News Bulletin
- Journal of Seed Production
- Journal of Seed Technology
- New Seed Journal
- Plant Varieties and Seeds
- Seed Abstracts
- Seed Research
- Seed Science & Technology
- Seed Science Research

e-Resources

- Ag Biotech Reporter www.bioreporter.com
- Agricultural Research Magazine www.ars.usda.gov/is/AR/
- American Seed Trade Association www.amseed.com
- Association of Official Seed Certifying Agencies www.AOSCA.org
- Association of Official Seed Analysts www.aosaseed.com
- Commercial Seed Analysts Association of Canada www.seedanalysts.com
- Front Range Seed Analysts www.frusa.org
- International Seed Federation www.wordseed.org
- International Seed Testing Association www.seedtest.org
- International Society for Seed Science www.css.comell.edu/ISSS/issss.htm
- International Society of Seed Technologists www.isstech.org
- The Seed Biology web page at Cornell University www.css.comell.edu/seedbio/seedbio.html
- Seed Biology at the Laboratory of Plant Physiology at the Wageningen University www.wau.nl/uk/organisation
- The Ohio State Seed Biology webpage www.css.ohio-state.edu/%7Eseedbio/
- The Seed Biotechnology Center University of California http://sbc.ucdavis.edu
- Seed Viability and Storage Research Unit www.ars-grain.gov/ars/NoPlains/FtCollins/preservation.htm
- Seed World www.seedworld.com
- Seed Quest www.seedquest.com
- Seed Today www.seedtoday.com/info/ST sites.html
- The South African National Seed Organization www.sansor.org/index.htm
- Society of Commercial Seed Technologists www.seedtechnology.net
- Wageningen Seed Centre www.seedcentre.nl

Suggested Broad Areas for Master’s and Doctoral Research

- Isolation distance requirements in view of GM varieties
- Review of seed certification standards
- GOT seasonal requirements
- Genetic purity vs-a-vis trait purity
- Enhancement of pollen viability, stigma receptivity and seed setting
- Reduction of processing losses
- Alternate areas / protected cultivation methods for hybrid seed production
- Standardising processing needs in high value crops and forage grasses
- Protein and oil content in GM cotton seed and its effect on longevity
- Optimisation of hybrid seed production technology in field crops, vegetables and flowers
- Pollen collection methods and viability testing
- Management of seed borne diseases with biocontrol agents
- Seed enhancement for unfavorable conditions
- Identification of markers for hybrid confirmation and genetic purity testing
- GM seed testing
- Seed testing protocols and seed standards for forage crops, medicinal species and spices
- Molecular control of seed viability, vigour and invigoration
- Standardisation of priming, coating and pelleting technologies
- Development of technologies for maintenance of parental lines of SI and MS based hybrids
- Any other location specific problems
## Course Structure

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**SERVICE COURSE**

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*Compulsory for Master’s programme; **Compulsory for Doctoral programme

* To be taught jointly by Soil Science and Microbiology
Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

UNIT-I: Scope of soil physics and its relation with other branches of soil science; soil as a three phase system.

UNIT-II: Soil texture, textural classes, mechanical analysis, specific surface.

UNIT-III: Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.

UNIT-IV: Soil structure - genesis, types, characterization and management soil structure; soil aggregation; aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT-V: Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT-VI: Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT-VII: Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

UNIT-VIII: Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

UNIT-IX: Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Practical

- Mechanical analysis by pipette and international methods
- Measurement of Atterberg limits
- Aggregate analysis - dry and wet
- Measurement of soil-water content by different methods
- Measurement of soil-water potential by using tensiometer and gypsum blocks
- Determination of soil-moisture characteristics curve and computation of pore-size distribution
- Determination of hydraulic conductivity under saturated and unsaturated conditions
- Determination of infiltration rate of soil
- Determination of aeration porosity and oxygen diffusion rate
- Soil temperature measurements by different methods
- Estimation of water balance components in bare and cropped fields

Suggested Readings

SOILS 502 SOIL FERTILITY AND FERTILIZER USE 3+1 SEM - I

Objective
To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory
UNIT-I: Soil fertility and soil productivity; nutrient sources and fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.
UNIT-II: Soil and fertilizer nitrogen sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.
UNIT-III: Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkaline soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.
UNIT-IV: Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.
UNIT-V: Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.
UNIT-VI: Micronutrients critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.
UNIT-VII: Common soil test methods for fertilizer recommendations; quantity intensity relationships; soil test crop response correlations and response functions.
UNIT-VIII: Fertilizer use efficiency; blanket fertilizer recommendations usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management.
UNIT-IX: Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical
Ä Principles of colorimetry
Ä Flame-photometry and atomic absorption spectroscopy
Ä Chemical analysis of soil for total and available nutrients
Ä Analysis of plants for essential elements

Suggested Readings
Objective
To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory
UNIT-I: Chemical (elemental) composition of the earth’s crust and soils.
UNIT-II: Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.
UNIT-III: Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.
UNIT-IV: Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny’s concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.
UNIT-V: Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.
UNIT-VI: Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.
UNIT-VII: Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.
UNIT-VIII: Chemistry and electrochemistry of submerged soils.

Practical
Â Determination of CEC and AEC of soils
Â Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter
Â Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
Â Potentiometric and conductometric titration of soil humic and fulvic acids
Â (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Â (E4/E6) values at two pH values
Â Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm
Â Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved
Â Determination of titratable acidity of an acid soil by BaCl2-TEA method
Â Determination of lime requirement of an acid soil by buffer method
Â Determination of gypsum requirement of an alkali soil

Suggested Readings
SOILS 504  SOIL MINERALOGY, GENESIS, 2+1 SEM - II  
CLASSIFICATION AND SURVEY

Objective
To acquaint students with basic structure of aluminosilicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory
UNIT-I: Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.
UNIT-II: Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils.
UNIT-III: Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.
UNIT-IV: Concept of soil individual; soil classification systems—historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps—usefulness.
UNIT-V: Soil survey and its types; soil survey techniques - conventional and modern; soil series—characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.
UNIT-VI: Landform—soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)—concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality
- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

Suggested Readings

SOILS 505  SOIL EROSION AND CONSERVATION 2+1 SEM - II

Objective
To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.
Theory

UNIT-I: History, distribution, identification and description of soil erosion problems in India.
UNIT-II: Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.
UNIT-IV: Principles of erosion control; erosion control measures Î¬ agronomical and engineering; erosion control structures - their design and layout.
UNIT-V: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.
UNIT-VI: Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical
- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Visits to a watersheds

Suggested Readings

SOILS 506/
MICRO 504
(To be taught jointly by Soil Science and Microbiology)

Objective
To teach students regarding basics of microbiology related to soil including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory
UNIT-I: Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.
UNIT-II: Microbiology and biochemistry of root - soil interface; phyllosphere, Biofertilizers, soil enzyme activities and importance.

Practical
Determination of soil microbial population; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification. N2 fixation, S oxidation, P solubilization and mineralization of other micro-nutrients; Study of rhizosphere effect.

Suggested Readings
SOILS 507 GEOMORPHOLOGY AND GEOCHEMISTRY 2+0 SEM - II

Objective
To impart knowledge about the landforms, physiography and morphology of the earth surface, and distribution and weathering elements in the earth crust.

Theory
UNIT-I: General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India.
UNIT-II: Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape.
UNIT-III: Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

Suggested Readings

SOILS 508 RADIOISOTOPES IN SOIL AND PLANT STUDIES 1+1 SEM - II

Objective
To train students in the use of radioisotopes in soil and plant research.

Theory
UNIT-I: Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter.
UNIT-II: Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography.
UNIT-III: Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating.
UNIT-IV: 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 $^{32}$P/ $^{65}$Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of $^{15}$N enrichment by mass spectrophotometry/ emission spectrometry

Suggested Readings

SOILS 509 SOIL, WATER AND AIR POLLUTION 2+1 SEM - II

Objective
To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.
Theory
UNIT-I: Soil, water and air pollution problems associated with agriculture, nature and extent.
UNIT-II: Nature and sources of pollutants - agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.
UNIT-III: Sewage and industrial effluents - their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.
UNIT-IV: Pesticides - their classification, behavior in soil and effect on soil microorganisms.
UNIT-V: Toxic elements - their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.
UNIT-VI: Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases - carbon dioxide, methane and nitrous oxide.
UNIT-VII: Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical
- Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents
- Heavy metals in contaminated soils and plants
- Management of contaminants in soil and plants to safeguard food safety
- Air sampling and determination of particulate matter and oxides of sulphur
- Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

SOILS 510 REMOTE SENSING AND GIS TECHNIQUES 2+1 SEM - 1 FOR SOIL, WATER AND CROP STUDIES

Objective
To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

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

Practical
- Familiarization with different remote sensing equipments and data products
- Interpretation of aerial photographs and satellite data for mapping of 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

**Suggested Readings**


**SOILS 511**

**ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS**

**Objective**

To familiarize the students with commonly used instruments, their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

**Practical**

**UNIT-I**: Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

**UNIT-II**: Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

**UNIT-III**: Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods.

**UNIT-IV**: Electrochemical titration of clays; determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

**UNIT-V**: Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

**UNIT-VI**: Determination of lime and gypsum requirement of soil; drawing normalized exchange isotherms; measurement of redox potential.

**UNIT-VII**: Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

**Suggested Readings**

- Piper CE. *Soil and Plant Analysis*. Hans Publ.
SOILS 512  SYSTEM APPROACHES IN SOIL AND CROP STUDIES

Objective
To train the students in concepts, methodology, technology and use of systems simulation in soil and crops studies.

Theory
UNIT-I: Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study.
UNIT-II: 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.
UNIT-III: Simulation - meaning and threats; simulation experiment, its design and analysis.
UNIT-IV: 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

Suggested Readings
Rajaraman V. 2004. Computer Programming in Fortran 90 and 95. PHI.

 Websites
• http://www.icasa.net/dssat/index.html for DSSAT; http://www.brc.tamus.edu/epic/ for EPIC
• http://www.nrel.colostate.edu/projects/century/ for Century
• http://www.alterra.wur.nl/NL/for WOFOST
• http://eco.wiz.uni-kassel.de/ecobas.html online Register of ecological models
• Plentinger MC Penning de Vries FWT, Editors (1996) CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO)
• Agricultural Systems Elsevier at http://www.elsevier.com/wps/product/cws_home/405851
• Ecological Modeling Elsevier at http://www.elsevier.com/locate/ecolmodel

SOILS 513  MANAGEMENT OF PROBLEM SOILS AND WATERS

Objective
To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.
Theory
UNIT-I: Area and distribution of problem soils - acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.
UNIT-II: Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties.
UNIT-III: Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.
UNIT-IV: Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.
UNIT-V: Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.
UNIT-VI: Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical
- Characterization of acid, acid sulfate, salt-affected and calcareous soils
- Determination of cations (Na+, K+, Ca++, and Mg++) in ground water and soil samples
- Determination of anions (Cl-, SO4 --, CO3 -- and HCO3 -) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils

Suggested Readings
USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.

SOILS 514 FERTILIZER TECHNOLOGY 1+0 SEM - II

Objective
To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory
UNIT-I: Fertilizers - production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order.
UNIT-II: Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents.
UNIT-III: Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order.
UNIT-IV: New and emerging issues in fertilizer technology - production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations.

Suggested Readings
Prasad R & Power JF. Soil Fertility Management for Sustainable Agriculture. CRC Press.

SOILS 515 LAND DEGRADATION AND RESTORATION 1+0 SEM - II

Objective
To impart knowledge related to various factors and processes of land degradation and their restoration techniques.
Theory

UNIT-I: Type, factors and processes of soil/land degradation and its impact on soil productivity, including soil fauna, biodegradation and environment.

UNIT-II: Land restoration and conservation techniques - erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products.

UNIT-III: Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Readings


Greenland DJ & Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.


SOILS 601 ADVANCES IN SOIL PHYSICS 3+0 SEM - II

Objective

To provide knowledge of modern concepts in soil physics.

Theory

UNIT-I: Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.

UNIT-II: Fundamentals of fluid flow, Poiseuilles law, Laplaceâ€™s equation, Darcyâ€™s law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcyâ€™s law; numerical solution for one dimensional water flow.

UNIT-III: Theories of horizontal and vertical infiltration under different boundary conditions.


UNIT-V: Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil.

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

UNIT-VII: Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Suggested Readings


SOILS 602 ADVANCES IN SOIL FERTILITY 3+0 SEM - II

Objective

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

UNIT-I: Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.
UNIT-II: Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.
UNIT-III: Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils.
UNIT-IV: Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.
UNIT-V: Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.
UNIT-VI: Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings


SOILS 603 PHYSICAL CHEMISTRY OF SOILS 2+0 SEM - II

Objective

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

Theory

UNIT-I: Colloidal chemistry of inorganic and organic components of soils ï their formation, clay organic interaction.
UNIT-II: Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer.
UNIT-III: Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction.
UNIT-V: Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).
SOILS 604  SOIL GENESIS AND MICROPEDOLOGY  2+0  SEM - I

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

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

Suggested Readings

SOILS 605  BIOCHEMISTRY OF SOIL ORGANIC MATTER  2+0  SEM - I

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

Theory
UNIT-II: Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.
UNIT-IV: Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.
UNIT-V: Humus - pesticide interactions in soil, mechanisms.

Suggested Readings
SOILS 606 LAND USE PLANNING AND WATERSHED MANAGEMENT

Objective
To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

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

Suggested Readings
SOIL SCIENCE

List of Journals

Â Advances in Agronomy
Â Annals of Arid Zone
Â Australian Journal of Agricultural Research
Â Australian Journal of Soil Research
Â Biology and Fertility of Soils
Â Communications in Soil Science and Plant Analysis
Â Clays and Clay minerals
Â European Journal of Soil Science
Â Geoderma
Â Indian Journal of Agricultural Sciences
Â Journal of Plant Nutrition and Soil Science
Â Journal of the Indian Society of Soil Science
Â Nutrient Cycling in Agroecosystems
Â Plant and Soil
Â Soil and Tillage Research
Â Soil Biology and Biochemistry
Â Soil Science
Â Soil Science Society of America Journal
Â Soil Use and Management
Â Water, Air and Soil Pollution
Â Water Resources Research

Suggested Broad Topics for Master’s and Doctoral Research

Â Degradation and restoration of soil as natural resource
Â Biochemistry of processes at the soil-root interface
Â Impact of current agricultural practices and agrochemicals on soil quality/biodiversity
Â Integrated nutrient management for sustainable agriculture
Â Fertilizer use efficiency in different soil conditions/cropping systems
Â Use of remote sensing and GIS as diagnostic tool for natural resource management
Â Role of biological agents in soil productivity
Â Modeling solute (salt, fertilizer, pesticides) transport in soil
Â Use of poor quality waters in Agriculture
Â Soil testing and crop response
Â Site-specific nutrient management and precision agriculture
Â Nutrient dynamics in soil-plant system and modeling nutrient uptake
Â Tillage and crop residue management in crop production
Â Utilization of urban and industrial wastes/effluents in Agriculture
Â Management of problematic soils
Â Impact of climate change on soil processes
Â Micronutrients in soil, plant and human health
Â Water management strategies in different cropping systems
Â Simulation models for growth and production of different crops
Â Varieties response to soil salinity/sodicity/nutrients/pollutants, etc
Â Soil and water pollution - monitoring and control
Â Genesis, formation and classification of soils
Â Soil conservation, preservation and management for sustainable agriculture
Â Remediation of polluted and contaminated soils
### Course Structure

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**SERVICE COURSES**

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*Compulsory for Master's programme; **Compulsory for Doctoral programme
One course of Genetics & Plant Breeding of 3 credits is compulsory as Minor/Supporting

To be taught by: 1 Vegetable Science; 2 Molecular Biology & Biotechnology
VEGETABLE SCIENCE

Course Contents

VSC 501 PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS  2+1 SEM - 1

Objective
To educate production technology of cool season vegetables.

Theory
Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT-I: Potato.
UNIT-II: Cole crops: cabbage, cauliflower, knoll kohl, sprouting broccoli, Brussels sprout.
UNIT-III: Root crops: carrot, radish, turnip, and beetroot.
UNIT-IV: Bulb crops: onion and garlic.
UNIT-V: Peas and broad bean, green leafy cool season vegetables.

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

Suggested Readings
VSC 502  PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS

Objective
To teach production technology of warm season vegetables.

Theory
Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:

UNIT-I: Tomato, eggplant, hot and sweet peppers.
UNIT-II: Okra, beans, cowpea and cluster bean.
UNIT-III: Cucurbitaceous crops.
UNIT-IV: Tapioca and sweet potato.
UNIT-V: Green leafy warm season vegetables.

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

Suggested Readings
Pandey AK & Mudranalay V. (Eds.). Vegetable Production in India: Important Varieties and Development Techniques.
VSC 503 BREEDING OF VEGETABLE CROPS 2+1 SEM - I

Objective
To educate principles and practices adopted for breeding of vegetable crops.

Theory
Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT-I: Potato and tomato.
UNIT-II: Eggplant, hot pepper, sweet pepper and okra.
UNIT-III: Peas and beans, amaranth, chenopods and lettuce.
UNIT-IV: Gourds, melons, pumpkins and squashes.
UNIT-V: Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca.

Practical
Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk, screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

Suggested Readings
Paroda RS & Kalloo G. (Eds.), 1995. Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region. FAO.
Peter KV & Pradeepkumar T. 2008. Genetics and Breeding of Vegetables. Revised, ICAR.
Swarup V. 1976. Breeding Procedure for Cross-pollinated Vegetable Crops. ICAR.
VSC 504

GROWTH AND DEVELOPMENT OF VEGETABLE CROPS

Objective
To teach the physiology of growth and development of vegetable crops.

Theory
UNIT-I: Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production.
UNIT-II: Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinins and abscissic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.
UNIT-III: Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops; apical dominance.
UNIT-IV: Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.
UNIT-V: Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops.

Practical
Preparation of solutions of plant growth substances and their application; experiments in breaking and induction of dormancy by chemicals; induction of parthenocarpy and fruit ripening; application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in Solanaceous vegetables; growth analysis techniques in vegetable crops.

Suggested Readings
Wien HC. (Ed.). 1997. The Physiology of Vegetable Crops. CABI.

VSC 505/
SST 504

SEED PRODUCTION IN VEGETABLES

Objective
To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training.

Theory
UNIT-I: Introduction; modes of propagation in vegetables; Seed morphology and development in vegetable seeds; Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.
UNIT-II: Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.
UNIT-III: Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, Cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.
UNIT-IV: Share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

Practical
Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; exercises on emasculation and pollination; seed extraction methods and their effect on quality of vegetables; seed production technology of varieties and hybrids in vegetables.

Suggested Readings
George RAT. 1999. *Vegetable Seed Production*. 2nd Ed. CABl.
Singh NP, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.

**VSC 506 **
**SYSTEMATICS OF VEGETABLE CROPS **
**1+1 **
**SEM - I **
(Unit-I to be taught by Botany)

**Objective**
To teach morphological, cytological, and molecular taxonomy of vegetable crops.

**Theory**
UNIT-I: Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops.
UNIT-II: Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.
UNIT-III: Cytological level of various vegetable crops; descriptive keys for important vegetables.
UNIT-IV: Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

**Practical**
Identification, description, classification and maintenance of vegetable species and varieties; survey, collection of allied species and genera locally available; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

**Suggested Readings**
Peter KV & Pradeepkumar T. 2008. *Genetics and Breeding of Vegetables*. (Revised), ICAR.
VSC 507 PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS

Objective
To educate production technology of underexploited vegetable crops.

Theory
Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

UNIT-I: Asparagus, artichoke and leek.
UNIT-II: Brussels sprout, Chinese cabbage, broccoli, kale and artichoke.
UNIT-III: Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods) and chekurmanis.
UNIT-IV: Elephant foot yam, lime bean, winged bean, vegetable pigeon pea, jack bean and sword bean.
UNIT-V: Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

Practical
Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of underexploited vegetables.

Suggested Readings

VSC 508 ORGANIC VEGETABLE PRODUCTION TECHNOLOGY

Objective
To educate principles, concepts and production of organic farming in vegetable crops.

Theory

UNIT-I: Importance, principles, perspective, concept and component of organic production of vegetables.
UNIT-II: Organic production of vegetables crops, viz., Solanaceous crops, cucurbits, cole crops, root and tuber crops.
UNIT-III: Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.
UNIT-V: GAP and GMP- Certification of organic products; organic production and export-opportunity and challenges.

Practical
Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, water management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings
VSC 509  FUNDAMENTALS OF PROCESSING OF 2+1  SEM - II  VEGETABLES

Objective
To educate principles and practices of processing of vegetable crops.

Theory
UNIT-I: Present status and future prospects of vegetable preservation industry in India.
UNIT-II: Spoilage of processed horticultural products; biochemical changes and enzymes associated with spoilage of horticultural produce; principal spoilage organisms, food poisoning and their control measures; role of microorganisms in food preservation.
UNIT-III: Raw materials for processing, Primary and minimal processing; processing equipments; Importance of hygiene; Plant sanitation.
UNIT-IV: Quality assurance and quality control, Food standards ñ FPO, PFA, etc. Food laws and regulations.
UNIT-V: Food safety ñ Hazard analysis and critical control points (HACCP). Labeling and labeling act, nutrition labeling.
UNIT-VI: Major value added products from vegetables. Utilization of byproducts of vegetable processing industry; Management of waste from processing factory.
UNIT-VII: Principles and methods of sensory evaluation of processed vegetables.

Practical
Study of machinery and equipments used in processing of horticultural produce; Chemical analysis for nutritive value of processed vegetables; Study of different types of spoilage in processed horticultural produce; study of biochemical changes and enzymes associated with spoilage; Laboratory examination of vegetable products; Sensory evaluation of processed vegetables; study of food standards ñ National, international, CODEX Alimentarius; Visit to processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

Suggested Readings
FAO. 1997. Fruit and Vegetable Processing. FAO.
FAO. CODEX Alimentarius: Joint FAO/WHO Food Standards Programme. 2nd Ed. Vol.
VB. Tropical Fresh Fruits and Vegetables. FAO.
FAO. Food Quality and Safety Systems – Training Manual on Food Hygiene and HACCP. FAO.
Hildegrade H & Lawless HT. 1997. Sensory Evaluation of Food. CBS.
VSC 510/ PSMA 502

PRODUCTION TECHNOLOGY OF SPICE CROPS

2+1 SEM - II

Objective

To impart basic knowledge about importance and production technology of spices grown in India.

Theory

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, pharmaceutical significance and protected cultivation of:

UNIT-I: Black pepper, cardamom.
UNIT-II: Clove, cinnamon and nutmeg, allspice.
UNIT-III: Turmeric, ginger and garlic.
UNIT-IV: Coriander, fenugreek, cumin, fennel, ajowain, dill, celery.
UNIT-V: Tamarind, garcinia and vanilla.

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice crops.

Suggested Readings

Gupta S. (Ed.). Hand Book of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.

VSC 511

POST HARVEST TECHNOLOGY OF VEGETABLE CROPS

2+1 SEM - II

Objective

To facilitate understanding on principles, and to acquaint with the proper handling and management technologies of vegetable crops for minimizing post harvest losses.
Theory

UNIT-I: Importance and scope of post harvest management of vegetables.
UNIT-II: Maturity indices and standards for different vegetables; methods of maturity determinations; biochemistry of maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, regulation methods.
UNIT-III: Harvesting tools, harvesting practices for specific market requirements; post-harvest physiological and biochemical changes, disorders-chilling injury in vegetables, influence of pre-harvest practices and other factors affecting post harvest losses, packaging house operations, commodity pretreatments- chemicals, wax coating, prepackaging and irradiation; packaging of vegetables, post harvest, diseases and prevention from infestation, principles of transport.
UNIT-IV: Methods and practices of storage- ventilated, refrigerated, MA, CA storage, hypobaric storage, pre-cooling and cold storage, zero energy cool chamber; storage disorders.

Practical

Studies on stages and maturing indices and ripening of commercially important vegetable crops, studies of harvesting, pre cooling, pre treatments, pre packaging, physiological disorders - chilling injury; improved packing, use of chemicals for ripening and enhancing shelf life of vegetables, physiological loss in weight of vegetables estimation of transpiration, respiration rate, ethylene release, storage of important vegetables, cold chain management - visit to commercial packaging house, cold storage and CA storage.

VSC 601 ADVANCES IN VEGETABLE PRODUCTION 2+1 SEM - I

Objective

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

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and bio-fertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost poly house; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT-I: Tomato, brinjal, chilli, sweet pepper and potato.
UNIT-II: Cucurbits, cabbage, cauliflower and knol-khol.
UNIT-III: Bhendi, onion, peas and beans, amaranthus and drumstick.
UNIT-IV: Carrot, beet root and radish.
UNIT-V: Sweet potato, tapioca, elephant foot yam and taro.

Practical

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

Suggested Readings

Brewster JL. 1994. Onions and other Vegetable Alliums. CABI.
FFTC. Improved Vegetable Production in Asia. Book Series No. 36.

VSC 602 ADVANCES IN BREEDING OF VEGETABLE CROPS

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

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

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

Suggested Readings

VSC 603 PROTECTED CULTIVATION OF VEGETABLE CROPS

Objective
To impart knowledge in growing of vegetable crops under protected environmental conditions.

Theory
Crops: Tomato, capsicum, cucumber, melons and lettuce.
UNIT-I: Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT-II: Regulatory structures used in protected structures; types of greenhouse/polyhouse/net-house, hot beds, cold frames, effect of environmental factors, viz. temperature, light, CO2 and humidity on growth of different vegetables, manipulation of CO2, light and temperature for vegetable production, fertigation.

UNIT-III: Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT-IV: Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT-V: Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

Practical
Study of various types of structures, methods to control temperature, CO2 light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/poly house/net house/shade house in the region.

Suggested Readings

VSC 604/ FLA605/ MBB 604
ADVANCES IN CROP BIOTECHNOLOGY 3+0 SEM - I
(To be taught by Molecular Biology & Biotechnology)

Objective
To teach advances in biotechnology for improvement of vegetable crops.

Theory
UNIT-I: Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available tissue culture, transformation, molecular marker and genomic tools for crop improvement.
UNIT-II: 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.
UNIT-III: 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 of qualitative and quantitative traits.
UNIT-IV: Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major cereal, legume oilseed, vegetable and horticultural crops.

Suggested Readings

VSC 605 ABIOTIC STRESS MANAGEMENT IN 2+1 SEM - II VEGETABLE CROPS

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

Theory
UNIT-I: Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of anti-transpirants.
UNIT-II: Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.
UNIT-III: Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.
UNIT-IV: Techniques of vegetable growing under water deficit, water logging, salinity, and sodicity.
UNIT-V: Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical
Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

Suggested Readings
VEGETABLE SCIENCE

List of Journals

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

Suggested Broad Topics for Master’s and Doctoral Research

- Organic farming in vegetable crops
- Application of molecular markers in genetic improvement of vegetable crops
- Development of transgenic vegetables
- Growing vegetables under protected conditions
- Mulching in vegetable crops
- Micronutrients in vegetable crops
- Screening of vegetable s against abiotic stress
- Hi-tech methods for raising nursery of vegetable crops
- Dry land and coastal farming
- Drip/micro irrigation in vegetable crops
- Fertigation in vegetable crops
- Research on physiological disorders in vegetable crops
- Breeding for quality improvement
- Breeding for insect-pest and disease resistance
- Breeding for extending shelf life of vegetable crops
- Minimal processing of vegetables
- Concept of quality control in vegetable seed production
- Integrated nutrients management in vegetable crops
- Breeding for industrial and processing of vegetable crops
- Research on water management in vegetable crops
- Research on home storage of vegetable crops
- Hi-tech home gardening