

**Faculty of Agricultural Sciences  
Rajiv Gandhi University**



**POST GRADUATE CURRICULA & SYLLABUS**

**M.Sc. (Agriculture)  
w.e.f. 2020 onwards**

**Syllabus structured as per ICAR V<sup>th</sup> Deans Committee Report**

## **Courses and Syllabi**

1. **Agricultural Economics -**
2. **Agronomy -**
3. **Animal Husbandry and Dairying -**
4. **Entomology and Agricultural Zoology -**
5. **Extension Education -**
6. **Farm Engineering -**
7. **Genetics and Plant Breeding -**
8. **Horticulture -**
9. **Mycology and Plant Pathology -**
10. **Plant Physiology –**
11. **Soil Science and Agricultural Chemistry**

1. **Agricultural Economics –**

## **M.Sc. (Ag.) Courses**

### **Core Courses**

#### **AEC 501 MICRO ECONOMIC THEORY AND APPLICATIONS 2(2+0)**

##### **Theory**

UNIT I Theory of Consumer Behaviour - Cardinal Utility Approach - Ordinal Utility Approach - Income effect and substitution effect - Applications of Indifference curve approach - Revealed Preference Hypothesis - Consumer surplus - Derivation of Demand curve - Elasticity of demand.

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.

UNIT III Market Equilibrium - Behavior of Firms in Competitive Markets - Perfect Competition- Effect of

Taxation and Subsidies on market equilibrium - Monopoly- Monopolistic - Oligopoly- Theory of Factor Markets.

UNIT IV General Equilibrium Theory - Welfare Economics - Pareto Optimality - Social welfare criteria - Social Welfare functions.

#### **AEC 502 MACRO ECONOMICS AND POLICY 2(2+0)**

## **Theory**

UNIT I Nature and Scope of Macro Economics - Methodology and Keynesian Concepts National Income - Concepts and measurement- Classical theory of Employment and Say's Law-Modern theory of Employment and Effective Demand.

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 III Money and classical theories of Money and Price - Keynesian theory of money and Friedman Restatement theory of money - Supply of Money - Demand for Money -Inflation: Nature, Effects and control.

UNIT IV IS & LM frame work - General Equilibrium of product and money markets Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy - Central banking.

UNIT V Business cycles - Balance of Payment - Foreign Exchange Rate determination.

## **AEC 503 EVOLUTION OF ECONOMIC THOUGHT 1(1+0)**

### **Theory**

UNIT 1 Approaches for the study of history of economic thought - Absolutist vs. Relativist approaches - Evolution of Economic Thought vs. Economic History. Ancient economic thought - medieval economic thought

- mercantilism - physiocracy - Forerunners of Classical Political Economy.

UNIT II Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo) - Critics of Classical Thoughts- Socialist critics - Socialist and Marxian Economic Ideas - Austrian School of Thought - Origins of Formal Microeconomic Analysis - William Stanley Jevons, Cournot and Dupuit.

UNIT III The birth of neoclassical economic thought - Marshall and Walras - General Equilibrium Theory - Welfare Theory - Keynesian economics.

UNIT IV The Era of globalization - Experiences of developing world - Rigidity of the past vs. emerging realism

- The changing path of international Institutions to economic growth and development approaches.

UNIT V Economic Thought in India - Naoroji and Gokhale - Gandhian Economics - Economic thought of independent India - Nehru's economic philosophy - Experiences of the Structural adjustment programmes of the post liberalization era.

## **AEC 504 AGRICULTURAL PRODUCTION ECONOMICS 2(1+1)**

### **Theory**

UNIT I Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

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.

UNIT III Cost functions and cost curves, components, and cost minimization -Duality theory - cost and production functions and its applications -Derivation of firm's input demand and output supply functions

- Economies and diseconomies of scale.

UNIT IV Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

**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.

**AEC 505 AGRICULTURALMARKETING AND PRICE ANALYSIS 3(2+1)**

**Theory**

UNIT I Review of Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production - Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical coordination.

UNIT II Marketing Co-operatives - APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousing and other Government agencies - Performance and Strategies -Market infrastructure needs, performance and Government role - Value Chain Finance.

UNIT III Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service electronic auctions (e-bay), e-Chaupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) - Market extension.

UNIT IV

Spatial and temporal price relationship - price forecasting - time series analysis - time series models - spectral analysis. Price policy and economic development - non-price instruments.

UNIT V

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

**Practical**

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

## **AEC 506 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 2(1+1)**

### **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 nonprobability 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.

UNIT IV Data collection - assessment of data needs - sources of data collection - discussion of different situations. Mailed questionnaire and interview schedule - structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule - problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey - Reconnaissance survey and Pre testing.

UNIT V Coding editing - tabulation - validation of data. Tools of analysis - data processing. Interpretation of results - Preparing research report / thesis - Universal procedures for preparation of bibliography - writing of research articles.

### **Practical**

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

## **AEC 507 ECONOMETRICS 3(2+1)**

### **Theory**

UNIT I Introduction - relationship between economic theory, mathematical economics, models 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**

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

## **AEC 508 LINEAR PROGRAMMING 2(1+1)**

### **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.

## **AEC 509 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT 3(2+1)**

### **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.

UNIT III Financial Decisions - Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm.

UNIT IV Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques - Undiscounted measures. Time value of money - Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques - PERT and CPM.

UNIT V Risks in financing agriculture. Risk management strategies and coping mechanism. Crop

Insurance programmes - review of different crop insurance schemes - yield loss and weather based insurance and their applications.

### **Practical**

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.

## **AEC 510 INTERNATIONAL ECONOMICS 2(1+1)**

### **Theory**

UNIT I Scope and Significance of International Economics - The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) - Equilibrium in a Simple Open Economy - Possibility of World Trade - Trade gains and Trade Equilibrium.

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 - Offer Curve - Export Supply Elasticity and Import Demand Elasticity - Comparative Advantage and Absolute Advantage.

UNIT IV Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade - Trade Blocks. UNIT V IMF, World Bank, IDA, IFC, ADB - International Trade agreements - Uruguay Round - GATT - WTO.

### **Practical**

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

## **AEC 511 AGRICULTURAL DEVELOPMENT AND POLICIES 2(2+0)**

### **Theory**

UNIT I Development Economics - Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development - GNP as a measure of economic growth - New Measures of Welfare - NEW and MEW

- PQLI - HDI - Green GNP Criteria for under development - Obstacles to economic development - Economic and Non-Economic factors of economic growth.

UNIT II Economic development - meaning, stages of economic development, determinants of economic growth. Theories of economic growth - Ricardian growth model - The Harrod - Domar Model - The Neo classical Model of Growth - The Kaldor Model - 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 III Role of agriculture in economic / rural development - theories of agricultural development - Population and food supply - need for sound agricultural policies - resource policies - credit policies - input and product marketing policies - price policies.

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

## **AEC 512 INSTITUTIONAL ECONOMICS 1(1+0)**

### **Theory**

UNIT I Old and New Institutional Economics - Institutional Economics Vs Neo- classical Economics. Definition of institutions - Distinction between institutions and organizations - Institutional evolution

UNIT II Institutional change and economic performance - national and international economic institutions. Transaction cost economics - Transaction costs and the allocation of resources. Transaction costs and efficiency. Asymmetric information - Moral hazard and Principal-Agent problem.

UNIT III Free rider problem - path dependency - Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem - theory of Groups. Rent seeking - interest groups and policy formulation.

UNIT IV Economic analysis of property rights- property rights regimes - private property - State Property - Common property Resources (CPRs) - public goods and club goods.

UNIT V Special features of institutional arrangements in agriculture - Transaction costs in agriculture - Case Studies - Theories of agrarian institutions - tenancy institutions.

## **AEC 513 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS 2(1+1)**

### **Theory**

UNIT I Concepts, Classification and Problems of Natural Resource Economics - Economy Environment interaction - The Material Balance principle, Entropy law-Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity - Malthusian and Recardian scarcity - scarcity indices - Resource Scarcity and Technical Change.

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 III Efficiency and markets - market failures - externalities - types - property rights - transaction costs - Coase's theorem and its critique - public goods - common property and open access resource management - Collective action.

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.

UNIT VI Concept of sustainable development - Economic Perspective - Indicators of sustainability Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting - resource accounting methods - International Environmental Issues - climate change - likely impacts mitigation efforts and international treaties.

### **Practical**

Exhaustible resource management -optimum rate of oil extraction. Renewable resource management - optimum harvest of Forestry/fishery. Exercise on pollution abatement -I. Exercise on pollution abatement -II. Concepts in valuing the environment. Taxonomy of valuation techniques. Productivity change method - substitute cost method - Hedonic price method - Travel cost method -Contingent valuation methods. Discount rate in natural resource management. Environment impact assessment Visit to Pollution Control Board.

## **AEC 514 INTELLECTUAL PROPERTY MANAGEMENT**

**1(1+0)**

### **Theory**

UNIT I World Trade Organization- Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR) - Importance of Intellectual Property Management - IPR and Economic growth- IPR and Bio diversity -Major areas of concern in Intellectual Property Management -Technology Transfer and Commercialization-Forms of different Intellectual Properties generated by agricultural research.

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 III Plant genetic resources -Importance and conservation - Sui Generic System -Plant Varieties Protection and Farmers Rights Act- Registration of Extant varieties -Registration and protection of New Varieties / Hybrids / Essentially Derived Varieties - Dispute prevention and settlement -Farmers' Rights.

UNIT IV Trademark- Geographical Indications of Goods and Commodities - Copy rights-Designs - Biodiversity Protection.

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 .

## **AEC 515 RURAL MARKETING 2(2+0)**

### **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's behaviour - behavior of rural consumers and farmers; buyer characteristics and buying behaviour; Rural v/s 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.

## **AEC 516 COMMODITY FUTURE TRADING**

**2(2+0)**

### **Theory**

UNIT I History and Evolution of commodity markets - Terms and concepts: spot, forward and futures Markets - factors influencing spot and future markets. Speculatory mechanism in commodity futures.

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.

## **AEC 517/ ABM 513: COMPUTER APPLICATIONS FOR AGRI-BUSINESS & ECONOMICS# 3(2+1)**

### **Contents**

UNIT I Concept of Computers- Brief History of Computers, Generation and Its Evolution, Characteristics of Computers, Hardware and Software, introduction to computer languages, Main Areas of Computers and their Applications; Types of Computers Analog, Digital, Hybrid, General Purpose and Special Purpose Computers, Micro Computers, Mini-Computers, Main-frame Computers, and Super Computers.

#### UNIT II

Input-Output Devices, Storage Units ( Disks, CD-ROM, DVD-ROM, Blue Ray Disk and tapes), Memory Types ( Cache, RAM, ROM), Memory Units, Generation and types of Microprocessor.

#### UNIT III

Data and Information - Data Definition, Data Processing Systems, Data Type Numeric, Alphabetic,

Audio, Graphic, and Video and Their Presentation; Data Processing- Introduction to Data Processing, Computer as a Tool For Data Processing, Data Processing Cycle, Data Processing Techniques, Data Analysis, Data Inputs and Outputs, Data Processing Management, , Data Security.

UNIT IV Introduction to Operating Systems, MS Windows, and UNIX, MS Office (MS Word, MS Power Point, MS Excel, MS-Access and use of various management software's Like SPSS. UNIT IV Introduction to LAN, WAN, MAN, internet and search engines; Introduction to agri-portals like agriwatch.com, agmarknet.nic.in, echaupal.com

**Practical :** Operation of various systems and software e.g. MS Windows, and UNIX, MS Office (MS Word, MS Power Point, MS Excel, MS-Access and use of various management software's Like SPSS. Data Processing and analysis. Network setting and practical utility of networking in agricultural economics.

**Agronomy –**  
**M.Sc. (Ag.) Courses**

**Core Courses**

**AGR 501 Modern Concepts in Crop Production 3(3+0)**

**Theory**

UNIT I

Crop growth analysis in relation to environment; agro-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; physiology of crop yield, optimization of plant population and planting geometry in relation to different resources, ideotypes, crop modelling.

UNIT IV

Crop response and production functions; concept of soil plant relations; yield and environmental stress.

UNIT V

Integrated farming systems, organic farming, and concept of conservation farming including modern concept of tillage, dry farming, concept of balance nutrition integrated nutrient management; precision agriculture.

**AGR 502 Principles and practices of Soil Fertility and Nutrient Management 3(2+1)**

**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 function, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients, chemistry of waterlogged soil.

Preparation and use of farmyard manure, compost, green manures, vermicompost, bio fertilizers 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 fertilizers 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 vermincompost and residue wastes in crop.

#### **Practical**

- Calculation of fertilizer use indices
- Determination of soil pH, ECe, organic C, total N, available N, P, K and S in soils
- Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima
- Calculation of fertilizer use indices

### **AGR 503 Principles and Practices of Weed Management 3(2+1)**

#### **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-herbicide, myco-herbicide and allelochemicals; Degradation of herbicides in soil and plant.

##### 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**

- Weed survey in crops and cropping systems
- Crop-weed competition studies
- Preparation of spray solution 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

## **AGR 504 Principles and Practices of Water Management 3(2+1)**

### **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; micro irrigation 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 membrane apparatus
- Soil-flow 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

## **AGR 505 Agrometeorology and Crop Weather Forecasting 3(2+1)**

### **Theory**

#### **UNIT I**

Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind.

#### **UNIT II**

Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature.

#### **UNIT III**

Temperature profile in air, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity vapour pressure and their relationships; evapotranspiration and meteorological factors determining evapotranspiration.

#### **UNIT IV**

Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation.

#### **UNIT V**

Weather forecasting in India - short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

### **Practical**

- Visit to agro-meteorological observatory and to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure
- Measurement of solar radiation outside and within plant canopy
- Measurement/estimation of evapo-transpiration by various methods
- Rainfall variability analysis
- Determination of heat-unit requirement for different crops measurement of crop canopy temperature
- Measurement of soil temperatures at different depths
- Visit to solar observatory

## **AGR 506 Agronomy of Major Cereals and Pulses 3(2+1)**

### **Theory**

#### UNIT I

Rabi cereals - Wheat, Barley, Maize, Winter Maize

#### UNIT II

Kharif cereals - Rice, Maize, Sorghum, Pearl millet, Minor Millets

#### UNIT III

Rabi pulses - Chickpea, Lentil, Fieldpea, Frenchbean

#### UNIT IV

Kharif pulses - Pigeonpea, Greengram, Blackgram.

### **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 size 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
- 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

## **AGR 507 Agronomy of Oilseed, Fibre and Sugar Crops 3(2+1)**

### **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

Kharif oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean etc.

#### UNIT II

Rabi oilseeds - Rapeseed and Mustard, Linseed, Safflower etc.

### UNIT III

Fiber crops - Cotton, Jute, Sun hemp etc.

### UNIT IV

Sugar crops - Sugar- beet and Sugarcane.

### **Practical**

- Determination of sugar crop maturity and calculation on purity percentage, recovery percentage and sucrose content in juice phenological studies at different growth stages of crop
- Intercultural operation in different crops
- Seed treatment & preparation of sugar crop planting material
- Working out growth indices (LER, CGR, RGR, NAR, LAD), aggressiveness, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping system
- 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 fiber of different 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 village for identification of constraints in crop production

### **AGR 508 Agronomy of Medicinal, Aromatic and 3(2+1) Under-Utilized Crops**

#### **Theory**

#### UNIT I

Importance of medicinal and aromatic plant in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and uses.

#### UNIT II

Climate and soil requirement; cultural practices; yield and important constituents of medicinal plants (Isabgol, Rauwolfia, Poppy, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nux vomica, Rosadla etc).

#### UNIT III

Climate and soil requirement; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium etc).

## UNIT IV

Climate and soil requirement; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, *Sesbania*)

### **Practical**

- Identification of crops based on morphological and seed characteristics
- Preparation 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

## **AGR 509 Agronomy of Fodder and Forage Crops 3(2+1)**

### **Theory**

#### UNIT I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crop like maize, bajra, guar, cowpea, oats, barley, sorghum, berseem, senji, lucerne etc.

#### UNIT II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses like, napier grass, Guineagram, Paragrass, Buffelgrass, Deenanath grass

#### 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

Seed production techniques.

### **Practical**

- Crop Cafeteria
- 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

## **AGR 510 Agrostology and Agro-Forestry 3(2+1)**

### **Theory**

#### **UNIT I**

Agrostology: definition and importance; principles of grassland ecology: grassland ecology - community, climax, dominant species, succession, biotype, ecological status of grassland in India, grass cover of India; problems and management of grassland.

#### **UNIT II**

Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pasture; 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 problem of seed germination in agro-forestry systems; irrigation and manuring in a agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economics 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 grass and trees in silvipastoral system
- Fertilization application in strip and silvipastoral systems
- After-care of plantation
- Estimation of protein content in lopping 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

## **AGR 511 Cropping Systems 2(2+0)**

### **Theory**

#### UNIT I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping system; assessment of land use.

#### UNIT II

Concept of sustainability in cropping systems and farming systems, scope and objectives; crop rotation, 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; factors of sustainability and research need

#### 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.

## **AGR 512 Dryland Farming 3(2+1)**

### **Theory**

#### UNIT I

Definition, concept characteristics of dry land and 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 areas; characterization of environment of water availability.

#### UNIT III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry areas; types of drought, wild season corrections for aberrant weather conditions, concept of water harvesting, techniques and practices, use of mulchos, kind, affectiveness and economic, anti transpirants.

#### UNIT IV

Tillage, tith, 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; soil and crop management techniques, seeding and efficient fertilizer use.

#### UNIT V

Concept of watershed resource management, problems, approach and components.

#### **Practical**

- Seed treatment, seed germination and crop establishment in relation to soil moisture contents
- Moisture stress effects and recovery behaviour of important crops
- Estimation of moisture index and aridity index
- Spray of anti-transparent and their effect on crops
- 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 dry land farming
- Visit to dry land research stations and watershed projects

#### **AGR 513 Principles and Practices of Organic Farming 3(2+1)**

#### **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 bio fertilizers.

##### UNIT III

Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

##### UNIT IV

Management of weeds, diseases and insect pest management by cultural, biological agents pheromones and bio pesticides.

## UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labelling and accreditation procedure; organic farming and national economy.

### **Practical**

- Aerobic and anaerobic methods of making compost
- Making of vermicompost
- Efficient use of bio fertilizer, 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 labelling and accreditation procedures for farm produce from organic farms

## **AGR 514 Field Experimentation 3(2+1)**

### UNIT I

Principles of field design, planning, layout and analysis of Completely Randomized design Randomized Complete Block Design and Latin Square design.

### UNIT II

Planning and analysis of Factorial experiments, Split plot and Strip Plot design.

### UNIT III

Concepts of confounding, complete and partial.

### UNIT IV

Interactions and their significance, production functions and their analyses.

### **Practical**

Layout of different designs in the field. Numericals, calculations; graphical representations of production functions. Field sampling and its analyses.

## **AGR-515 Management of Problem Soils 3(2+1)**

### **Theory**

### UNIT I

Origin, nature, properties, area and distribution of saline, sodic, calcareous, acid and waterlogged soils and basic concept of problematic soils, and factors responsible.

### UNIT II

Plant response to soil reaction, nutrient imbalance in saline, sodic and saline-sodic, acid and waterlogged soils; tolerance mechanisms.

### UNIT III

Extent of damage to crops by saline, acid and waterlogged soils; crop to clearance to salinity, sodicity, acidity and waterlogged.

### UNIT IV

Reclamation of problem soils, role of soil amendments and soil drainage; agronomic practices in relation to problem soils, cropping pattern for problem soils.

### **Practical**

- Characterization of salt-affected, calcareous, acid and waterlogged soils.
- Determination of soil pH, EC, CEC,
- Determination of anions ( $\text{Cl}^-$ ,  $\text{SO}_4^-$ ,  $\text{CO}_3^-$  and  $\text{HCO}_3^-$ ) in soil.
- Determination of cations ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ ) in soil.
- Lime and gypsum requirements of acid and sodic soils.

Visit to problematic areas to acquaint with production contranints.

UNIT III

# **M. Sc (Ag.) IN LIVESTOCK PRODUCTION AND MANAGEMENT COURSE**

**LPM 601 Cattle and Buffalo Production and Management  
3(2+1)**

## **Theory**

### UNIT I

Introduction - Development of Dairy Industry in India and world - Present status and future prospects of livestock development in India

### UNIT II

Important breeds of cattle and buffalo, traits of economic importance and their inter relationships - Selection of high quality animals - Role of management in improving the reproduction efficiency in farm animals. - Housing and rearing systems.

### UNIT III

Breeding Management: System of breeding Economic traits. Methods of Breeding - Prenatal and postnatal care and management of cattle and buffalo - Care of neonate and young calves - Management strategies for reducing mortality in calves, age at first calving and calving interval in cattle and buffaloes.

### UNIT IV

Management of labour, Milking management, Machine milking and hand milking, Different laws governing the livestock sectors to produce quality products on par with international standards - Technique of harvesting clean and hygienic livestock products, transportation of animals, health management. Wallowing in buffaloes- Management of draught animals and summer management

### UNIT V

Feed and fodder resources used for feeding of cattle and buffaloes- Scientific technique of feeding, watering - Computation of practical and economical ration, supply of green fodder around the year and enrichment of poor quality roughages.

## **UNIT Practical**

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

## **LPM 602 Sheep and Goat Production and Management 3(2+1)**

### **Theory**

#### **UNIT I**

Introduction - Population structure and importance- Advantages and disadvantages of sheep farming under different systems of management - type of housing and equipments- Important sheep and goat breeds- Advantages and disadvantages of sheep and goat farming.

#### **UNIT II**

Breeding Management: Breeding seasons - fitness of purchase for first breeding - methods of detection of heat - Natural Service and artificial insemination - Care of the pregnant Animals - Breeding stock - Use of teaser - Culling.

#### **UNIT III**

Feeding Management: Feeding methods - Principles to be followed in feeding and watering- feeder space, waterer space, Designing feeders and waterers. - Range management - Stocking rate and pasture improvement and utilization; management under stall fed conditions, Transportation of sheep and goat.

#### **UNIT IV**

Disease Management: Role of management in the prevention and control of diseases. Special Management: Deworming - Dipping and spraying- shearing - Avoidance of goatry odour in milk, Tipping.

#### **UNIT V**

Wool: Importance of wool - Fiber structure- Fleece characters - Goat fibers - Characters of mohair and pashmina, fur and Angora - Marketing of goat fibers / wool.- Planning of sheep and goat farm of various sizes - Economics of sheep and goat farming.

### **Practical**

Visit to sheep and goat farms and critical analysis of various managerial practices under different

UNIT II Conditions. Study of practical housing management - Analysis of practical diseases control management - Shearing management - Record keeping. - Preparation of project for commercial farming - Characterization of sheep and goats; handling of sheep and goat; daily and periodical operations for sheep and goats - Methods of identification of sheep and goat. Cost of rearing sheep and goat for mutton and wool - Housing plans for various age and categories of sheep and goat - Dipping; Vaccination of sheep and goat - Shearing of wool.

### **LPM 603 Swine Production and Management 2(1+1)**

#### **Theory**

##### UNIT I

Introduction - Population and importance - Economic contribution of pigs - Advantages and disadvantages of swine keeping - Systems of management - Problems in pig farming.

Breeds of pigs - Selection of breeding stock - Breeding seasons - Age and weight at first services - Methods for detection of heat - Natural service and artificial insemination - Care of pregnant sows, piglets and growers - Care of breeding boar.

##### UNIT III

Housing, sanitation and hygiene, disease prevention measures - Housing and equipment - Wallowing - Sanitation and hygiene - Role of management in the prevention and the control of diseases.

##### UNIT IV

Feeding and management of new born, weaner and finishers, dry, pregnant and farrowing sows - Feeding principles to be followed - Methods of watering - Feeder space - Waterer space, etc - Marketing: Methods of marketing in swine production - Record keeping.

#### **Practical**

Visits to piggeries and critical Analysis of various types of managerial practices - Analysis of the trend and structures of pig population - Analysis of practical breeding management methods, practical disease control management - special management methods - Ageing and identification - Judging - Constraints and remedial measures in pig farming - Economics of production - Project preparation for research and commercial farms.

### **LPM 604 Laboratoray Animal Production and Management 2(1+1)**

## UNIT II **Theory**

### UNIT I

Introduction - Importance of rabbit for meat and fur production, rats, mice and guinea pigs, - Common breeds and strains.

### UNIT II

System of housing - Common diseases and their control measure.

Management of specific pathogen free and gnotobiotic animals, concepts to related to welfare of laboratory animals

### UNIT III

Breeding - Age at maturity, litter size - Weaning - Feeding of growers - Selection of replacement stock, transportation of rabbit.

### UNIT IV

Transportation of Laboratory animals - marketing of meat and fur.

## **UNIT Practical**

Handling and restraining of laboratory animals - Visits to small animal farms and critical analysis of various types of managerial practices- Analysis of the trend and structures of Laboratory animals population - Analysis of practical breeding management methods - practical disease control management and special management methods - Ageing and identification - Judging - Economics of production.

### **LPM 605 Shelter Management 2(1+1)**

#### **Theory**

##### **UNIT I**

General principles in planning animal houses- farmstead and animal houses - Selection of site and planning; layouts for livestock farm of different sizes in different climatic zones in India - Farm structures - General principles of construction of enclosures, floor and road.

##### **UNIT II**

Housing requirements of different classes of Livestock - Preparation of layouts, plans, arrangement of alleys- Fitting and facilities in the houses for horses, dairy cattle, calves, bulls, work cattle, dogs, pigs, sheep, goats, and poultry.

##### **UNIT III**

Improvement of existing buildings; water supply; feed and fodder delivery systems - Economics of Livestock housing.

##### **UNIT IV**

Housing - Disease control measures and sanitation of all classes of livestock

#### **Practical**

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

### **LPM 606 Principles of Environmental Hygiene and Waste Management 2(2+0)**

**Theory**Animal air hygiene: Definition - Composition of air - Air pollution - Factors affecting outdoor and indoor pollution - Assessment of these factors on animal health and production - Methods to control these

factors.

#### UNIT II

Water Hygiene: Importance of water - Impurities and inclusions - Sterilization - Examination of water and water supplies - Collection of samples- Topographical physical, chemical, bacteriological and microscopic examination of water - Hygienic requirements and standards for drinking water - Quantity of water required by domestic animals - Methods of watering.

#### UNIT III

Manure - Quantity of manure voided by domestic animals - Animal excreta a factor in spread of disease - Hygienic and economic disposal of farm waste - Modern techniques used in automation / semi-automation in disposal of farm waste.

#### UNIT IV

Environmental protection act, Air (Prevention and control of pollution) act and water (Prevention and control of pollution) act - Biosecurity measures to be adapted for efficient and healthy production

#### UNIT V

Effect of environmental pollution on livestock and its products directly and indirectly - Controlling environmental pollution - Different factors affecting the quality of livestock and its products meant for human consumption.

### **LPM 607 Climatology and Animal Production 1(1+0)**

#### **Theory**

##### UNIT I

Definition of climate -Classification of climatic regions - Climatic factors- Assessment of climate - Study of climatic factors in relation to animal production.

##### UNIT II

Light, natural and artificial light-mechanism of light action-photo period and light responses - Applications - Importance of light in production of animals and birds.

Introduction of breeds into different climatic regions - Agro meteorology and weather forecasting for Animal Husbandry activities - Micro climate modification in animal houses.

UNIT III

Estimation of microclimatic conditions in Animal house - Measurement of Temperature, Relative humidity, Air Velocity and Mean temperature of the surrounding, measurement of intensity of light in animal houses - Construction of climographs and hythergraphs -Estimation of cooling power of atmosphere heat tolerance test in bovines.

**LPM 608 POULTRY FARM AND HATCHERY MANAGEMENT 3(2+1)**

**Theory**

UNIT I

Poultry housing systems Cage Vs floor system, litter management and lights for poultry, rearing turkey, duck and quails.

UNIT II

Management of chicks, growing, laying and breeding flocks, broiler production, selection and culling of laying flocks.

UNIT III

Procuring, care and pre-incubation storage of hatching eggs - Method of incubation, sanitation disinfection and management of hatchery.

UNIT IV

Embryonic development and factors effecting fertility and hatchability of eggs.

UNIT V

Chick sexing, packing and hatchery business - Transporting management of farm and hatchery waste.

**Practical**

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

**LPM 609 Farm Animal Behaviour**

**1(1+0)**

**Theory**

**UNIT I**

Introduction to Animal behaviour - Importance of animal behaviour studies - Patterns of behaviour - Daily and seasonal cycles of behaviour - Physiological basis of behaviour.

**UNIT II**

Environmental modification of behaviour - Developmental changes in behaviour - Genetic differences in behaviour - Behavioural disorders.

**UNIT III**

Group formation - Social relationship, process of socialisation locality and behaviour - Practical application - Behavioural character for managemental practices - Favourable and unfavourable behaviour for domestication - Behavioural adaptations under domestication.

**UNIT IV**

Physical environment and behaviour - Common vices and their remedial measures - Analysis of behaviour in relation to location - Analysis of behaviour in relation to climatic environment - Analysis of social behaviour.

**LPM 610 Integrated Livestock Farming System 3(2+1)**

**Theory**

**UNIT I**

Scope and limitation of integrated farming systems - Sustainability of integrated Livestock Farming Systems and their economic importance.

**UNIT II**

Integration of fish, arable farming and different livestock enterprises vis-a-vis gobar gas plant, FYM, solar and wind energy utilization, cattle, buffalo sheep, goat, pig, poultry, rabbit, silk worm, bee keeping etc.

**UNIT III**

New approach for changing farming systems in present energy crises.

**UNIT IV**

Project formulation and evaluation of various livestock enterprises.

### **Practical**

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

## **LPM 611 EQUINE PRODUCTION AND MANAGEMENT 2(1+1)**

### **Theory**

#### UNIT I

Equine population in India - Breeds of native and exotic horses - Types and classes of light and work horses.

#### UNIT II

Housing and routine management practices -Hygiene and maintenance of stable. Color and markings, Dentition and ageing selecting and judging horses- unsoundness and stable vices

#### UNIT III

Feeding and breeding of horses donkey and Mules, foaling, care of foal

#### UNIT IV

Foot care and shoeing care, Stud farms - Race clubs - Race horses and their care - Horse behaviour and training - Exercising - Basic Horsemanship

#### UNIT V

Health management & diseases control. Control of internal and external parasites of horse- Colic and its prevention

#### UNIT VI

Mode of transport - Facilities requirement - Cleaning, disinfection and preparation of vehicles Transport stress - Management during transport - Regulatory acts of states and centre in animal disease control and welfare. Precautions and requirements before, during and after transport - Laws governing the import and export of livestock and its products- - Horse passport and trading.

### **Practical**

Control of horse for examination, passing of stomach tube, dentition and ageing, saddling, exercising of horse, hoof care.

Pilliner S. 1994. *Care of the competition Horse*. BT Batsford.

Rose RJ & Hodgson DR. 2000. *Manual of Equine Practice*. WB Saunders.

## **LPM 612 Wild Life Management and Conservation 2(2+0)**

### **Theory**

#### UNIT I

Zoo and captive wild animals - Principles and concepts - Ecology of wild life sanctuaries and National parks- wild life legislation in India - Status of forest in India - Biological and ecological basis of management of wild life.

#### UNIT II

Voluntary organization on wild life - Rules and regulations of zoo authority of India -Wild life protection act - Zoological classification of wild animals - Funding agencies for wild life research and preparation of project. - Conservation of wild animals.

#### UNIT III

Wild life health control - Reproduction in zoos - Population analysis - Population manipulation - Habit analysis and design - The resources and its management - Distribution of important Indian animals - Zoo animals and birds - Breeding characteristics - Movements - Cover requirements - Food - Population density - Mortality - Nesting losses caused by predators, predator and prey relationship - Human interference - Refuge rehabilitation

#### UNIT IV

Restraints - Maps - Survey and plans of management systems - Principles, protective measures - Development and conservation of water supply- puberty - Breeding seasons - pregnancy - Parturition - Lactation postnatal survival of the young - Social factors among various species - Miscellaneous management procedures.

## **LPM 613 Livestock Business Management**

**2(1+1)**

## **Theory**

### UNIT I

Management principles - Planning - Techniques, strategic planning, organization structure, co-ordination and controlling techniques - Approaches to management.

### UNIT II

SWOT analysis, financial accounting - Accounting records - Balance sheet, fund flow statement - Cost and analysis for managerial decisions - Budgeting and control .

### UNIT III

Tools of financial analysis, working capital financing - Long term financial management - Investment analysis - Capital markets - Corporate risk management - Venture capital.

### UNIT IV

Marketing - Objectives, strategies - Selecting and managing marketing channels - Pricing strategies - Sales promotion - Legislation relating licensing - Company law.

## **Practical**

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

## **M. Sc (Ag.)**

# **DAIRY TECHNOLOGY**

### **DT 511 Advanced Dairy Processing 4(3+1)**

#### **Theory**

#### **UNIT I**

Use of bio-protective factors for preservation of raw milk: effects on physicochemical, microbial and nutritional properties of milk and milk products, present status of preservation of raw milk by chemical preservatives; thermal processing for preservation.

#### **UNIT II**

Methods of determining lethality of thermal processing, UHT processed milk products, their properties and prospects, types of UHT plants, aseptic fillers, heat stability and deposit formation aspects, effect on milk quality; techno- economic considerations; retort processing.

#### **UNIT III**

Principles and equipment for bacto-fugation and Bactotherm processes, Microfluidization of milk: Principle, equipment, effects and applications, Homogenization and their applications in dairy industry.

#### **UNIT IV**

Dehydration: advances in drying of milk and milk products; freeze concentration, freeze dehydration: physicochemical changes during freeze drying and industrial developments.

#### **UNIT V**

Water activity; sorption behaviour of foods, energy of binding water, control of water activity of different milk products in relation to their chemical; microbiological and textural properties; hurdle technology and its application in development of shelf-stable and intermediate-moisture foods, Use of carbonation in extending the shelf life of dairy products.

UNIT VI Current trends in cleaning and sanitization of dairy equipment: biological; detergents; Automation; Ultrasonic techniques in cleaning; bio-detergents, development of sanitizers- heat; chemical; radiation, mechanism of fouling and soil removal; Bio-films, assessing the effectiveness of cleaning and sanitization of dairy products.

## **Practical**

LP system for extension of keeping quality raw milk, determination of pH; HCT profile of milk systems, measurement of thiocyanate in milk system; determination of water activity and sorption isotherms of milk products; determination of thermal load during retort processing of milk and milk products; heat classification of milk powders; functional properties of powders: porosity, interstitial air content, occluded air content, flowability; determination of degree of browning- hemical/physical methods; freeze drying of milk/milk products, and heat sensitive products. Homogenization efficiency; cleaning efficiency in dairy equipment; visit to a UHT Processing plant. Thermal process calculations.

## **DT 512 Advanced Food Processing**

**4(3+1)**

### **Theory**

#### UNIT I

Status of food processing industry in India and abroad; prospects and constraints in development of Indian food industry.

#### UNIT II

Post harvest management of fruits and vegetables, Harvesting indices, Biochemical and physical changes during ripening of fruits & vegetables, respiration and factors affecting it, role of ethylene in accelerated ripening, post harvest treatments for extension of shelf-life of fresh produce, Strategic interventions to minimize post harvest losses including vapour heat treatment, wax coating, chemicals, etc.

#### UNIT III

Principles of chilling & refrigeration storage of foods, quality changes in cold stored products, controlled and modified atmospheric storage. Freezing of foods, principle and equipments for freezing, defects in frozen foods, recrystallization, freezing of fruits and vegetables, freeze concentration of fruit juices.

#### UNIT IV

Application of heat energy to foods for preservation and processing, concept of drying rate of foods, industrial drying processes of foods; changes during drying, advanced drying processes (Freeze drying, infra red drying and microwave drying), Canning of fruits & vegetables, unit processes involved in canning, types of cans for thermal processing of foods.

#### UNIT V

Basic principles involved in fermentation, Technological aspects of pickled vegetables like sauerkraut, cucumbers, Technology of wine, beer and distilled alcoholic beverages, defects in alcoholic beverages.

Conversion of muscle into meat, rigor mortis, freezing and canning of meat, curing & smoking of meat, fermented sausages, cooking of poultry, utilization of milk ingredients in processed meat and poultry products.

#### UNIT VII

Advances in milling of rice (solvent extractive milling) and Turbo milling of wheat. Bakery products; role of ingredients, Developments in manufacturing processes for bakery products such as breads; biscuits; pizza bases, cake etc; changes during processing of bakery products. Utilization and importance of dairy ingredients in bakery products.

#### UNIT VIII

Definition, classification and technologies of fabricated and formulated foods and their nutritional aspects. Imitation dairy products and dairy analogues. Principle of extrusion processing, design and working of extruder, classification, application in food and dairy processing. Food additives, including stabilizers, emulsifiers, antioxidants, preservatives, etc. for formulated foods.

#### UNIT IX

Important group of enzymes involved in food processing; Application of enzymes in food processes like enzymes juice extraction, juice clarification, in bread manufacture, meat tenderization, ice cream manufacture, desugaring of egg, etc.

#### UNIT X

Newer concepts in food processing including organic foods, processing of organic raw material, genetically modified foods.

#### **Practical**

MAP and its effect on shelf-life of fresh fruits and vegetables, Preparation of squash, cordial, nectar and whey beverages, whey based soups, Manufacture of bread, pizza base, biscuits and cake, Application of milk ingredients in caramel, egg-less cake, mayonnaise, canning of fruits & vegetables, manufacture of chicken soup, comminuted meat products, enzymatic extraction and clarification of fruit juices, Preparation of soymilk and tofu, Drying of fruits & vegetables, efficacy of blanching treatment. Manufacture of sauerkraut/fermented vegetables.

#### **DT 513 Rheology of Dairy & Food Products 3(2+1)**

## **Theory**

### UNIT I

Introduction to rheology of foods: Definition of 'texture', 'rheology' and 'psychophysics' - their structural basis; physical considerations in study of foods; salient definitions -Stress tensor and different kinds of stresses.

### UNIT II

Rheological classification of Fluid Foods : Shear-rate dependence and time dependence of the flow-curve; NonNewtonian fluids; thixotropy; Mechanisms and relevant models for non-Newtonian flow; Effect of temperature; Compositional factors affecting flow behaviour; Viscosity of food dispersions - dilute and semi-dilute systems, concentration effects.

### UNIT III

Comparative assessment of different types of Viscometers, and their Merits and Limitations: Co-axial cylinders, Spindle- or Impeller-type viscometers, Cone-plate viscometer, Capillary viscometers, Falling-sphere viscometer, Vibratory viscometers, Extrusion viscometer, Orifice viscometer.

### UNIT IV

Rheology of semi-solid and solid food ; Rheological characterization of foods in terms of stress-strain relationship; Viscoelasticity; Transient tests - Creep Compliance and Stress Relaxation; mechanical models for viscoelastic foods: Maxwell, Kelvin, Burgers and generalized models and their application; Dynamic measurement of viscoelasticity.

### UNIT V

Large Deformations and failure in foods: Definitions of fracture, rupture and other related phenomena; Texture Profile Analysis; Instrumental measurements - Empirical and Fundamental methods; Rheometers and Texture Analyzers; Measurement of Extensional viscosity; Acoustic measurements on crunchy foods.

**UNIT V** Rheological and textural properties of selected dairy products: Measurement modes and techniques; Effect of processing and additives (stabilizers and emulsifiers) on food product rheology; Relationship between instrumental and sensory data.

### **Practical**

Study of different types of viscometers viz., co-axial cylinder viscometer, spindle viscometer, falling-ball viscometer, extrusion viscometer, impeller viscometer, orifice viscometer; Flow behaviour of fluid dairy products; Thixotropy in ice-cream mix; force-deformation study in selected dairy products using Texture Analyzer; Back extrusion; Effect of test conditions on the texture profile parameters of cheese and similar products; stress relaxation studies in solid foods; Use of Cone Penetrometer and FIRANIRD extruder for measurement of butter texture; Use of a Viscoamylograph for study on the gelatinization behaviour of starch/cereals flours.

## **DT 514 DAIRY PROCESS BIOTECHNOLOGY 3(2+1)**

### **Theory**

#### **UNIT I**

Definition of biotechnology; development and impact of biotechnology on food and dairy industry.

#### **UNIT II**

Microbial rennet and recombinant chymosin, characteristics and application in cheese making; exogenous free and microencapsulated enzymes, immobilized enzymes-their application in accelerated ripening of cheese; enzymatically modified cheeses (EMC) their utilization in various food formulations.

#### **UNIT 3**

Technological requirements of modified micro-organisms for production of cheese and fermented milk products; technological innovations in the development of functional dairy foods with improved nutritional therapeutic and pro-biotic attributes; physiologically active bio-peptides/ nutraceuticals; protein hydrolysates - their physicochemical, therapeutic properties, production and application in food formulations; production of bioyoghurt, pro-biotic cheese and fermented milks; bifidus factors in infant food formulations.

#### **UNIT IV**

Protein hydrolysates-production, their physicochemical, therapeutic properties, de-bittering and application in food formulations; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages.

Microbial polysaccharides their properties and applications in foods, production of alcoholic beverages

UNIT V and industrial products from starch; whey and other by-products; bio-sweeteners-types properties and their applications in dairy and food industry.

#### UNIT VI

Bio-preservatives- characteristics and their application in enhancing the shelf life of dairy and food products.

#### **Practical**

Effect of exogenous enzymes on hydrolysis of protein and fat in culture containing milk systems; to study the various factors affecting the coagulation of milk by microbial rennets. Manufacture and evaluation of pro-biotic cheese and fermented milks; determination of glycolysis, proteolysis and lipolysis in cheese and fermented milk; enzymatic process for manufacture of low lactose milk whey products; preparation of casein hydrolysates; visit to a bio-processing unit.

#### **DT 515 Traditional and Value Added Products 3(2+1)**

#### **Theory**

##### UNIT I

Present status of traditional dairy products; globalization of traditional dairy products; plans and policies of the Government and developmental agencies.

##### UNIT II

Process schedule of heat-desiccated, coagulated and fermented traditional dairy products; process improvement in production of milk sweets.

##### UNIT III

New products based on fruits, vegetables and cereals; application of membrane technology; microwave heating for industrial production of traditional dairy products.

##### UNIT IV

Advances in industrial production of ghee, flavour and texture simulation.

##### UNIT V

Techno-economic aspects for establishing commercial units for traditional products.

Convenience traditional dairy products; use of natural and permitted synthetic preservatives and new packaging systems.

## UNIT ~~V~~ Practical

Microwave heating of traditional milk delicacies for shelf life extension; application of membrane technology for improving the quality of traditional products from cow and buffalo milk; preparation of feasibility report for establishing commercial units for traditional products.

### **DT 521 Membrane Technology in Dairy Processing 3(2+1)**

#### **Theory**

##### UNIT I

Membrane techniques: classification and characteristics of filtration processes; types of membranes commercially available; membrane hardware, design of membrane plants, modeling of ultrafiltration (UF) processes, mass transfer model, resistance model; membrane fouling-problem and treatment, cleaning and sanitization of different types of membranes.

##### UNIT II

Factors affecting permeate flux during ultrafiltration and reverse osmosis of milk and sweet and sour whey, energy requirements for processing of milk and whey.

##### UNIT III

Applications of ultrafiltration, reverse osmosis, nanofiltration and microfiltration in the dairy industry. Developments in the manufacture and utilization of food and pharmaceutical grade lactose from UF permeate. Preparation of special foods like low lactose powder and dairy whiteners using UF retentate, whey protein concentrates, casein and coprecipitates.

##### UNIT IV

Demineralisation: Importance of demineralisation, different processes available for demineralization: their principle, plant and operation.

##### UNIT V

Functional properties of whey proteins (WPC & WPI), casein, coprecipitates and UF milk retentate and their modifications. Evaluation of functional properties of proteins.

## **Practical**

Study of the effect of types of milk, temperature of milk and transmembrane pressure on the permeate flux during ultrafiltration process; performance of ultrafiltration membrane with respect to permeate flux and volume concentration ratio during processing of acid and sweet whey; study the effect of types of milk, temperature and applied pressure on the permeate flux during the reverse osmosis process; nanofiltration of milk, whey and permeate; microfiltration of skim milk and whey; preparation of whey protein concentrate and its utilization in dairy products; measurement of different functional properties of casein and whey protein: whipping ability; water binding; emulsification properties; gelling; viscosity and solubility.

## **DT 522 Advanced Dairy and Food Packaging 3(2+1)**

### **Theory**

#### UNIT I

Status of current packaging; types of packaging materials; criteria for selection of proper packaging; testing of packaging materials.

#### UNIT II

Adhesives; graphics; coding, and labeling used in food packaging.

#### UNIT III

Protective packaging of foods; packaging of food products sensitive to oxygen, light, moisture; active packaging; special problems in canned foods.

#### UNIT IV

Packaging of dairy products; packaging of convenience foods, packaging of fruits, vegetables, and fruit juices.

#### UNIT V

Packaging of fats and oils; packaging of spices; packaging of meat and poultry; packaging of fish and other seafoods.

#### UNIT VI

Modified atmosphere packaging, controlled atmosphere packaging, shrink and stretch packaging.

#### UNIT VII

UNIT- II

Retort pouch technology, microwavable, biodegradable, and edible packages.

#### UNIT VIII

Industrial packaging: unitizing, palletizing, containerising, distribution systems for packaged foods including prevention of shock damage to articles during transportation.

#### UNIT IX

Safety aspects of packaging materials; sources of toxic materials and migration of toxins into food materials.

#### **Practical**

Testing of packaging materials for quality assurance like determination of thickness, GSM, grease resistance, bursting strength, tearing resistance, WVTR, puncture resistance; estimation of shelf life of vegetables and seasonal fresh fruits; packaging of turmeric powder and ground red chilli powder, vacuum packaging of dairy products.

### **DT 523 ALTERNATIVE PROCESSES FOR DAIRY AND FOOD INDUSTRY 3(2+1)**

#### **Theory**

##### UNIT I

Irradiation: sources and properties of ionizing radiation; mechanism of interaction with microorganisms and food components microbial inactivation in dairy and food products, chemical effects, packaging, industrial irradiation systems, benefits and limitations; safety aspects, national and international regulations.

##### UNIT II

High frequency heating: Principles of dielectric heating and factors affecting it, design and working of microwave oven, continuous microwave heating units, applications in dairy and food processing, microwavable packaging safety aspects of microwaves, merits and demerits of dielectric heating.

##### UNIT III

Infra-red heating: Interaction of infra-red (IR) radiation with penetration properties, equipment; dairy and food application, advantages and disadvantages of IR heating.

##### UNIT IV

Ohmic heating: Principle of electric resistance heating, design of an ohmic heater, operational variables, power considerations, factors affecting heating efficiency, merits and limitations, food applications and future scope.

## UNIT V

Ultrasonic treatment of food: Mechanism of ultrasound induced cell damage, generation of ultrasound equipment, design of power ultrasonic system, types of ultrasonic reactors, application of power ultrasound in food processing, effects on food constituents, ultrasound in consideration with other process alternatives - thermosonication, advantages and future prospects.

## UNIT VI

High hydrostatic pressure processing: Principle of microbial inactivation, barotolerance of microorganisms, effect on food constituents, equipment, dairy and food application, merit and demerits.

## UNIT VII

Pulsed electric field processing: Description/ mechanism and factors affecting microbial inactivation effects on food components; present status and future scope for food applications.

### **Practical**

Study of a microwave oven; Determination of power output of a microwave oven; Temperature profile in a microwave oven cavity; Microwave absorption by various food packaging materials; Heating behaviour of water, milk, cream and other milk products - effect of composition; Shelf-life extension of pasteurized milk employing microwave heating; Effect of shape and size of water/milk container on microwave heating; Cooking of 'instant' products in a microwave oven; Drying of casein, 'instant' wheat, 'instant' rice, etc. in a microwave oven; Miscellaneous food processing/heating applications of microwaves; Visit to a commercial food irradiation facility.

## **DT 524 FUNCTIONAL FOODS AND NEW PRODUCT DEVELOPMENT 4(3+1)**

### **Theory**

#### UNIT I

Definition, classes of functional foods, status of functional foods in world and India. Concept of new product development, classes of nutraceuticals and functional foods. Safety; marketing strategy and consumer response; economic analysis and costing of novel foods, recent advances in different categories and type of dairy product.

#### UNIT II

Nutritional status and dietary requirement of different target group and deficiency diseases, in special reference to micronutrients. Dietary and therapeutic significance of dairy nutrients, bioactive components in dairy products like lactose, whey proteins, milk minerals, CLA, fermented milks etc.

#### UNIT III

Food fortification, techniques for fortifying dairy foods with minerals and vitamins, High protein foods prospective nutraceuticals for fortification of dairy foods. Nutritional significance of dietary fibers, classes

of dietary fibers, fortification techniques for fibers in dairy foods.

Infant nutrition and dietary formulations for meeting normal and special needs of infants, current status of infant foods, additives for infant foods. Foods for aged persons, design consideration, ingredients for geriatric foods.

#### UNIT V

Technological aspects of reduced calorie foods, alternatives for calorie reduction, low calorie sweeteners, bulking agents and their application, fat replacers and their utilization in low calorie dairy foods.

#### UNIT VI

Nutritional and health significance of sodium in foods, Alternatives for sodium in foods, techniques for reducing sodium in processed dairy foods. Bio-flavours and flavour enhancers.

#### UNIT VII

Sports foods, ingredients for sports foods, dairy components in sports foods, sports drinks, design consideration, ergogenic aids in sports nutrition.

#### UNIT VIII

Herbs, various classes of herbs, their therapeutic potential and application in foods with special reference to dairy products like functional drinks, herbal ghee etc.

#### UNIT IX

Prebiotic substances and their utilization in functional foods, symbiotic foods, technological aspects and recent development in probiotics, prebiotics and synbiotics.

#### UNIT X

Definition and various classes of phytochemicals, their role in CVD, Cancer and immune system enhancer, utilization in functional foods, phytosterol, phytoestrogens, glucosinolates, organosulphur compounds, flavonoids, carotenoids, etc.

#### UNIT XI

Special foods/nutrients for CVD, cancer, IBD, diabetics, persons suffering 21 with milk allergy and lactose intolerance with special emphasis on dairy nutrients and foods.

### **Practical**

Determination of total fiber, neutral detergent fiber in foods; manufacture of fiber enriched milk beverage; manufacture of low calorie burfi/ice cream; preparation of flavoured milk using artificial

sweetener and its estimation; determination of antioxidant activity of food/food components; determination of bioavailability of nutrients; development of malted milk food and weaning food; determination of P-galactosidase activity and application of lactases for lactose free dairy products determination of prebiotic potential of certain plant/milk components and their application in synbiotics dairy foods preparation of sports beverage, herbal dairy drinks; preparation of high protein products.

### **DT 525 Technology of Food Emulsions, Foams and Gels 3(2+1)**

#### **Theory**

##### UNIT I

Food dispersions, their characteristics and factors affecting food dispersions.

##### UNIT II

Food emulsions; emulsifiers and their functions in foods; the HLB concept in food emulsifiers; emulsion formation and stability; polymers and surfactants.

##### UNIT III

Milk foams and their applications, structure of foams, egg foams and uses, foam formation and stability.

##### UNIT IV

Theory of gel formation; pectic substances and jellies; fruit pectin gels; milk jellies.

##### UNIT V

Structure of dairy foods representing emulsions, foams and gels; physical structure of fat rich, concentrated, fermented, coagulated and dried products.

##### UNIT VI

Techniques for evaluation of structure for food emulsions, foams and gels.

#### **Practical**

Determination of the rate of formation and stability of emulsions; Emulsifying properties of milk proteins and other food ingredients; Properties of different types of emulsifiers and their role in food emulsions; Examination of foam formation and determination of foam stability; Milk proteins and other food ingredients in food foams; foaming in dairy systems; Studies on gel formation and gel properties; Food gels - Gelatinbased, pectin-based, etc.; Properties of various gelling agents for foods.





Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota - Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera - Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

#### UNIT -III

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera - Subdivision Endopterygota, Section Neuropteroid-Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, 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, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

**ENT 505**

**Insect Ecology**

**2(1+1)**

#### **Objective**

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

#### **Theory**

##### UNIT -I

History and Definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

##### UNIT -II

Basic concepts of abundance- Model vs Real world. Population growth basic models - Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population

dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

#### UNIT -III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of nicheecological homologues, competitive exclusion. Prey-predator interactions- Basic model- Lotka-Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

#### UNIT- IV

Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's  $d/w$ , Relation between the two and their association with Dyar's Law and Prizbram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology.

#### **Practical**

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

**ENT 506**

**Insect Pathology**

**2(1+1)**

#### **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.

#### UNIT -III

Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests.

### **Practical**

Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

## **ENT 507 Biological Control of Crop Pests and Weeds 2(1+1)**

### **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.

#### UNIT - IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

### **Practical**

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

## **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 organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrololes, 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.

## **ENT 509 Plant Resistance to Insects 2(1+1)**

### **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.

### **ENT 510 Principles of Integrated Pest Management 2(1+1)**

#### **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, Physical, mechanical chemical and biological 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.

#### **Practical**



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.

#### **ENT 513 Storage Entomology 2(1+1)**

#### **Theory**

##### UNIT- I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto visa - 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- Nonchemical 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).

## **ENT 514 Insect Vectors of Plant Viruses and Other Pathogens**

**2(1+1)**

### **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.

**ENT 515**

**General Acarology**

**2(1+1)**

**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; extraction of mites from soil, plants 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.

**ENT 516 Soil Arthropods and Their Management 2(1+1)**

**Theory**

UNIT- I

Soil arthropods and their classification, habitats and their identification.

UNIT -II

Estimation of populations; sampling and extraction methods.

UNIT -III

Role of soil arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropods as bio-indicators of habitat qualities. Effect of soil arthropod activity on soil properties.

UNIT -IV

Harmful and beneficial soil arthropods and their management, interrelationship 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.

### **ENT 517 Vertebrate Pest Management**

**2(1+1)**

#### **Theory**

##### UNIT -I

Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds.

##### 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 (LD<sub>50</sub> 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.

### **ENT 518**

### **Techniques In Plant Protection**

**1(1+0)**

#### **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, corms, cuttings and cut flowers.

### UNIT -III

Use of light, transmission and scanning electron microscopy.

### UNIT- IV

Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

### UNIT -V

Use of tissue culture techniques in plant protection. Computer application for predicting/ forecasting pest attack and identification.

## **ENT 519                      Commercial Entomology    2(1+1)**

### **Theory**

#### UNIT -I

Bee keeping- General colony management during different seasons. Seasonal management. Managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honey bees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries.

#### 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.

#### UNIT -IV

Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and postconstruction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methods of domestic pest management.

### **Practical**

Assessing pest status in dwellings (labs, canteen or hostel), implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre- and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes

and special adaptations, identification and handling of bee keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm rearing and management. Lac host and crop management technology and processing of lac. Products and by-products of lac.

### **ENT 520 Plant Quarantine 2(2+0)**

#### **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 -II**

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

##### **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.

## **Extension Education – M.Sc. (Ag.) Courses**

### **EXT 501 Development Perspectives of Extension Education**

**2(1+1)**

#### **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 III**

Poverty Alleviation Programmes - SGSY, SGRY, PMGSY, DPAP, DDP, CAPART - Employment Generation Programmes - NREGP, Women Development Programmes - ICDS, MSY, RMK, Problems in Rural Development.

##### **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.

### **EXT 502 Development Communication and Information Management 3(2+1)**

#### **Objective**

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

#### **Theory**

##### **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 - Meaning, characteristics and their role in development.

#### UNIT III

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.

### **EXT 503 Diffusion and Adoption of Innovations 3(2+1)**

#### **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 InnovationDecisions - 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.

## **EXT 504 Research Methods in Behavioural Science 3(2 + 1)**

### **Theory**

#### **UNIT I**

Research - Meaning, importance, characteristics. Behavioural sciences research - Meaning, concept and problems in behavioural sciences research. Types and methods of Research - Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Review of literature - Need, Search Procedure, Sources of literature, Planning the review work. Research problem - Selection and

Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem.

#### **UNIT II**

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

#### **UNIT III**

Research Designs - Meaning, purpose and criteria for research design, Types, advantages and limitations of each design. Experimental design - Advantages and limitations. Data Collection devices - Interview - Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules - Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires - Meaning, difference between schedule and questionnaire, types of questions to be used, pre - testing of the questionnaires or schedules and advantages and limitations. Check lists -

Meaning, steps in construction, advantages and limitations in its use. Rating scales - Meaning, types, limits in construction, advantages and limitations in its use. Observation - Meaning, types, tips in observation, advantages and limitations in its use. Case studies - Meaning, types, steps in conducting, advantages and limitations in its use. Social survey - Meaning, objectives, types and steps in conducting, advantages and limitations.

#### UNIT IV

Data processing - 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 - 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.

### **EXT 505 E- Extension 3(2+1)**

#### **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 the 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.

##### UNIT III

Community Radio, Web, Tele, and Video conferencing. Computer Aided Extension. Knowledge management, Information kiosks, Multimedia. Online, Offline Extension. Tools-Mobile technologies, e-learning concepts.

##### UNIT IV

ICT: Extension approaches-pre-requisites, information and science needs of farming community. Need integration. Human resource information. Intermediaries. Basic e-extension training issues. ICT enabled extension pluralism. Emerging issues in ICT.

#### **Practical**

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

### **EXT 506 Entrepreneurship Development and Management in Extension 3(2+1) Theory UNIT I**

Entrepreneurship - Concept, characteristics, Approaches, Theories, Need for enterprises development. Agri - entrepreneurship - Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs - Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise - Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal - Market, Technical, Financial, Social Appraisal of Projects.

#### 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.

#### UNIT III

Management - Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management - Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning - Concept, Nature, Importance, Types, Effective making planning. Change Management - factors, process and procedures. Decision making - Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing - Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations.

#### UNIT IV

Coordination - Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization. Staffing - Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development - Performance appraisal - Meaning, Concept, Methods. Direction - Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership - Concept, Characteristics, Functions, Approaches to leadership, Leadership styles. Organizational Communication - Concept, Process, Types, Networks, Barriers to Communication. Managing work motivation - Concept, Motivation and Performance, Approaches to motivation. Supervision - Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective

supervision. Managerial Control - Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

### **Practical**

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

### **EXT 507 Human Resource Development (HRD) 3(2+1) Objective**

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

### **Theory**

#### **UNIT I**

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

#### **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 - communication and feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning,

Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building - Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager - Responsibility of Professional Manager; Managerial skills and Soft Skills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics :Leadership styles - Group dynamics.

#### **UNIT III**

Training - Meaning, determining training need and development strategies - Training types, models,

methods and evaluation; Facilities for training - Trainers training - techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate - organizing for HRD - emerging trends and Prospectives.

### **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.

## **EXT 508 Visual Communication 3(2+1) Theory**

### UNIT I

Role of visuals & graphics in Communication. Characteristics of visuals & graphics. Functions of visuals and graphics. Theories of visual perception. Classification and selection of visuals.

### UNIT II

Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and production of low cost visuals.

### UNIT III

Photographs- reprographic visuals. PC based visuals. Digitized video material in multimedia production. Designing visuals for print and TV and video.

### UNIT IV

Pre-testing and evaluation of visuals. Scanning of visuals.

### **Practicals**

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

## **EXT 509 Participatory Methods for Technology Development and Transfer 2(1+1) Theory**

### UNIT I

Participatory extension - Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.



## 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.

## **EXT 510 Gender Sensitization for Development 3(2+1) 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 -need and relevance; Gender budgeting - A tool for empowering women.

#### UNIT III

Women empowerment -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.

### **EXT 511 Perspectives of Distance Education 2(2+0) 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 - Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education - Evolution and Historical view of Distance Education - Theory Methodology, and Epistemology. Dimensions of Distance Education, Scope and difficulties. Open Education - Non-formal Education, Continuing Education, Education by correspondence.

#### **UNIT II**

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 III**

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

#### **UNIT IV**

Educational Technology in 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 -Strategies for maximizing the reach - 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.

### **EXT 512 Market Led Extension 2(2+0) Theory**

#### **UNIT I**

Agricultural extension at cross roads; Changing scenario of agricultural extension at the national level;

Market led extension - emerging perspectives; Market led extension - issues and challenges; Dimensions of market led extension.

#### UNIT II

Agricultural marketing an overview; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Marketing communication and promotional strategies; The marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPRs agreements on agriculture; Agreement on SPS and TBT - an overview; Commodity features marketing.

#### UNIT III

Public private linkages in market led extension; Role of SHG in market led extension; Contract farming - a viable approach to meet market challenges; IT enabled approaches for market led extension and communication; Weather service and crop modeling - An effective tool in market led extension.

#### **Practical**

Identification and analysis of different marketing sources for agricultural commodities. Development of strategy for an effective market intelligence system; Development of suitable marketing plan to suite rural situation; Visit to APEDA, Rythu Bazaars to study the processes and procedures related to market-led extension.

## Farm Engineering –

### M.Sc. (Ag.) Courses

**STAT 501 Statistical Methods for Applied Sciences**

**3(2+1)**

#### **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 III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Testing for heterogeneity.

#### **Practical**

On the topics listed in the theory syllabus.

**STAT 502 Experimental Designs 3(2+1)**

#### **Theory**

##### UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

##### UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

##### UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

## **Practical**

On the topics listed in the theory syllabus.

## **STAT 511 Mathematical Methods for Applied Sciences 2(2+0)**

### **Theory**

#### UNIT I

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; maxima and minima in optimization.

#### UNIT II

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering.

#### UNIT III

Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and eigen vectors. Determinants - valuation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

## **STAT 512 Non Parametric Tests and Multivariate Analysis**

**3(2+1)**

### **Theory**

#### UNIT I

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

#### UNIT II

Introduction to multivariate analytical tools- Hotelling's  $T^2$  Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function,  $D^2$ -statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

### **Practical**

On the topics listed in the theory syllabus. Central and State Seed Testing Laboratories; Duties and powers of seed inspectors, offences and penalties; Seed control order: Seed Control Order 1983, Seed Act 2000 and other issues related to seed quality regulation. Intellectual Property Rights, Patenting, WTO, Plant Breeders Rights, Varietal Identification through Grow-Out Test and Electrophoresis; Seed Drying: Forced air seed drying, principle, properties of air and their effect on seed drying, moisture equilibrium between seed and air, Heated air drying, building requirements, types of air distribution systems for seed drying, selection of crop dryers and systems of heated air drying, recommended temperature and depth of the seeds, management of seed drying, Planning and layout of seed processing plant; Establishment of seed processing plant. Seed processing: air screen machine and its working principle, different upgrading equipments and their use, Establishing a seed testing laboratory. Seed

testing procedures for quality assessment, Seed treatment, Importance of seed treatment, types of seed treatment, equipment used for seed treatment (Slurry and Mist-O-matic treater), Seed packing and seed storage, stages of seed storage, factors affecting seed longevity during storage and conditions required for good storage, General principles of seed storage, constructional features for good seed warehouse, measures for pest and disease control, temperature control, Seed marketing, marketing structure, marketing organization, sales generation activities, promotional media, pricing policy; Factors affecting seed marketing.

**Practical:** Seed sampling principles and procedures; Physical Purity analysis of Field and Horticultural crops; Germination analysis of Field and Horticultural crops; Moisture tests of Field and Horticultural crops; Viability test of Field and Horticultural crops; Seed health test of Field and Horticultural crops; Vigour tests of Field and Horticultural crops; Seed dormancy and breaking methods; Grow out tests and electrophoresis for varietal identification; Visit to Seed production plots of Maize, Sunflower, Bajra, Rice, Sorghum, Cotton, Chillies and Vegetables. (Add or delete crops of the region); Visit to Seed processing plants; Visit to Seed testing laboratories; Visit to Grow out testing farms; Visit to Hybrid Seed Production farms; Varietal identification in seed production plots; Planting ratios, isolation distance, roguing etc.

# Genetics and Plant Breeding – M.Sc. (Ag.) Courses

## GP 501 Principles of Genetics

3(2+1)

### Theory

#### UNIT I

Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

#### UNIT II

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.

#### UNIT III

Population - Mendelian population - Random mating population - Frequencies of genes and genotypes - Causes of change: Hardy-Weinberg equilibrium.

#### UNIT IV

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

#### UNIT V

Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

#### UNIT VI

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.

#### UNIT VII

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

## UNIT VIII

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

## UNIT IX

Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts.

## UNIT X

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

### **Practical**

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis - basic principles and running of amplified DNA - Extraction of proteins and isozymes - use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

### **GP 502 Principles of Cytogenetics**

**3(2+1)**

### **Theory**

#### UNIT I

Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes.

#### UNIT II

Chromosomal theory of inheritance - Cell Cycle and cell division - mitosis and meiosis; Differences, significance and deviations - Synopsis, 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 III

Structural variation in chromosomes - their cytogenetical consequences, gene mapping and other uses; Deficiencies, duplications, inversions and interchanges; 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 genetic problems in crops with apomixes.

## 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.

## **Theory**

### UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.

### 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; Selection, Response to Selection; Population breeding-mass selection and ear-to-row methods; S<sub>1</sub> and S<sub>2</sub> progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

### 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**

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

### **GP 504 Principles of Quantitative Genetics**

**3(2+1)**

#### **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 III

Designs for plant breeding experiments - principles and applications; Genetic diversity analysis - metroglyph, cluster and D<sub>2</sub> analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

##### 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 - principles 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.

#### **Practical**

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D<sub>2</sub> analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation

of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Trialallel analysis, Quadriallel analysis and Triple

Test Cross (TTC) - use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted D<sub>1</sub> multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

### **GP 505 Mutagenesis and Mutation Breeding**

**3(2+1)**

#### **Objective**

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

#### **Theory**

##### 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 II

Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations *viz.*, X rays, Y rays and  $\theta$  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 III

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 M<sub>1</sub> generation: plant injury, lethality, sterility, chimeras *etc.*, - Observing mutagen effects in M<sub>2</sub> 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 M<sub>3</sub> generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species - Case studies.

#### UNIT VII

Use of mutagens in creating oligogenic and polygenic variations - Case studies - *in vitro* mutagenesis - callus and pollen irradiation; Handling of segregating generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc) in different crops- Procedures for micromutations 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 M<sub>1</sub> generation - Parameters to be observed; Study of M<sub>2</sub> 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 M<sub>2</sub> and M<sub>3</sub> generations.

## **GP 506 Population Genetics**

**3(2+1)**

### **Theory**

#### UNIT I

Population - Properties of population - Mendelian population - Genetic constitution of a population through time, space, age structure etc. Mating systems - Random mating population - Frequencies of genes and genotypes - Causes of change: population size, differences in fertility and viability, migration and mutation.

#### UNIT II

Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof - Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium - Mating frequencies - Non-dominance - Codominance - Snyder's ratio, importance and its effect over random mating in succeeding generations.

#### UNIT III

Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency - Migration - Mutation - Recurrent and nonrecurrent - Selection - Balance between selection and mutation - Selection favouring heterozygotes - Overdominance for fitness.

#### UNIT IV

Non random mating: selfing - inbreeding coefficient - panmictic index - sibmating - Assortative mating and disassortative mating - Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops.

#### UNIT V

Gene substitution and average effects; Breeding value - Genetic drift; Genetic slippage, Co-adapted gene complexes; Homeostasis - Adaptive organization of gene pools, Polymorphism - Balanced and Non-balanced polymorphism, heterozygous advantage - Survival of recessive and deleterious alleles in populations.

### **Practical**

Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average effect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium; Exercises of different mating designs; Estimation of different population parameters from experimental data.

## **GP 507 Heterosis Breeding**

**3(2+1)**

### **Theory**

## UNIT I

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops.

## UNIT II

Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis - Physiological, Biochemical and molecular factors underlining 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 F<sub>2</sub> and segregating populations, importance of inbreeding in exploitation of heterosis - case studies. - Relationship between genetic distance and expression of Heterosis - case studies; Divergence and Genetic Distance analyses- morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

## UNIT IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of selfincompatibility 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 V

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 VI

Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

## UNIT VII

Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum, pigeonpea and oilseed crops.

## **Practical**

Selection indices and selection differential - Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated

crops - Estimation from the various models for Heterosis parameters -Hybrid seed production in field crops - an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

**GP 508 Cell Biology and Molecular Genetics**

**3(2+1)**

### **Theory**

#### UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles - nucleus, plastidschloro/ chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

#### UNIT II

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 III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation - Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes - ribosomes, t-RNAs and translational factors.

#### UNIT IV

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.

### **Practical**

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method;

Determination of soluble protein content in a bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

## **GP 509 Biotechnology for Crop Improvement**

**3(2+1)**

### **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

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.), mapping populations (F<sub>2</sub>s, back crosses, RILs, NILs and DH).

#### UNIT IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, 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; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

#### UNIT VI

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases.

#### UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

#### UNIT VIII

GMOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights

#### 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 - 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.

### **GP 510 Breeding for Biotic and Abiotic Stress Resistance**

**3(2+1)**

### **Theory**

#### UNIT I

Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses - 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 hostdefense mechanisms against viruses and bacteria.

#### UNIT II

Types and genetic mechanisms of resistance to biotic stresses -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 -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, chitinases and Bt for diseases and insect pest management- Achievements.

### **Practical**

Phenotypic screening techniques for sucking pests and chewing pests - Traits to be observed at plant and insect level - Phenotypic screening techniques for nematodes and borers; Ways of combating them; Breeding strategies - Weeds - 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.

**GP 511 Breeding Cereals, Forages and Sugarcane**

**3(2+1)**

### **Theory**

#### UNIT I

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

#### UNIT II

Wheat: 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, 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 III

Maize: 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 - QPM and Bt maize - strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives yield, quality characters, biotic and abiotic stress resistance etc.

### UNIT IV

Sugarcane: 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 - Forage grasses: Evolution and distribution of species and forms - Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., synthetics, composites and apomixes.

### UNIT V

Forage legumes: 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 -

Tree fodders: 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*, palatability studies.

### 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 and their 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.

**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: Greengram, 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; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; 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 - characteristics 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 - characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VII

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm;

Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

#### 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 IX

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Development and maintenance of male sterile lines - Hybrid development and seed production - Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: 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*; Mesta and minor fibre crops: 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*.

#### 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 - 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 -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.

**GP 513 Breeding For Quality Traits**

**3(2+1)**

**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.

## **GP 514 Gene Regulation And Expression**

**2(2+0)**

## **Theory**

## UNIT I

Introduction: Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

## UNIT II

Coordinated genetic regulation-examples- Anthocyanin and gene families and maize.

## UNIT III

Gene expression-Transposons in plant gene expression, Paramutations and imprinting of genes and genomes.

## UNIT IV

Transgene expression and gene silencing mechanisms; Regulatory genes horizontal and vertical homology; Transformation regulatory genes as visible markers.

## UNIT V

Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress- induced gene expression.

## **GP 515 Maintenance Breeding and Concepts of Variety Release and Seed Production 2(1+1)**

### **Theory**

#### UNIT I

Variety Development and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid, and population; Variety testing, release and notification systems in India and abroad.

#### UNIT II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

#### UNIT III

Factors responsible for genetic deterioration of varieties - safeguards during seed production; Maintenance of varieties in self and cross-pollination crops- isolation distance; Principles of seed production; Methods of nucleus and breeder seed production.

#### UNIT IV

ragi etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, 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.

### **GP 516 Germplasm Collection, Exchange And Quarantine**

**3(2+1)**

### **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 transboundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

#### **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 GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

#### **GP 517 Data Base Management, Evaluation And Utilization Of PGR 3(2+1)**

#### **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 numograms; 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.

#### 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 agrobiodiversity 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.

## **M.Sc. (Ag). Courses - Horticulture**

### **HOR 501 Tropical And Dry Land Fruit Production 3(2+1)**

#### **Theory**

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone, nutrient management, water management, fertigation, role of plant growth regulators, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, pest and disease management, physiological disorders- systems, causes and remedies, quality improvement by management practices; maturity indices, harvesting,; industrial and export potential and Agri. Export Zones(AEZ).

#### **Crops**

UNIT I: Mango and Banana

UNIT II: Citrus and Papaya

UNIT III: Guava, Sapota and Jackfruit

UNIT IV: Pineapple, Annonas, Avocado and Bael

UNIT V: Aonla, Pomegranate, Phalsa and Ber

**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 of commercial orchards.

**HOR 502 Production Technology Of Warm Season Vegetable Crops 3(2+1)**

**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, plant protection measures, 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 regulators

**HOR-121 Production Technology of Vegetables and Flowers 3(2+1)**

Importance of Olericulture, vegetable gardens, vegetable classification. Origin, area, production, varieties, package of

practices for fruit vegetables- tomato, brinjal, chillies and okra; Cucurbitaceous vegetables- cucumber, bottle gourd, bitter

gourd and melons; Cole crops- cabbage and cauliflower; Bulb crops- onion and garlic; Beans and peas- French bean, dolichos

beans and peas; Tuber crops- potato and sweet potato; Root crops- carrot and radish; Leafy vegetables- amaranthus and palak;

Perennial vegetables- drumstick and coccinia. Importance of floriculture and ornamental gardens. Planning of ornamental

gardens. Types and styles of ornamental gardens. Use of trees, shrubs, climbers, palms, foliage, succulents and seasonal

flowers in the gardens. Package of practices for rose, jasmine, chrysanthemum, carnation, marigold, tuberose and gladiolus.

**Practical:** Planning and layout of kitchen garden; identification of important vegetable seeds and plants; raising of vegetable

nurseries; identification of ornamental plants (trees, shrubs, climbers, foliage, succulents, palms etc.) and development of

garden features; transplanting of vegetable seedlings; layout of lawns and maintenance; seed extraction in tomato and brinjal.

Repotting and depotting and maintenance of ornamental plants; visit to commercial vegetable farms; training and pruning of

rose (standards, hybrid “T” and scented) and chrysanthemum (pinching and disbudding); planning and layout of gardens and

garden designs for public and private areas; intercultural operations in vegetable plots; seed production in vegetable crops;

harvest indices of different vegetable crops; grading and packaging of vegetable; prolonging the vase life of cut flowers.

### **HOR- 211 Production Technology of Spices, Aromatic, Medicinal and Plantation Crops 3(2+1)**

Importance and cultivation technology of spices - clove, ginger, turmeric, black pepper, cardamoms, nigella coriander, cumin,

fenugreek; aromatic crops- lemon grass, citronella, palmarose, vetiver, geranium, dawana; plantation crops – coconut,

arecanut, betelvine, cashew, cocoa, coffee, tea, oilpalm; medicinal plants- dioscoria, rauvolphaa, opium, ocimum, perwinkle,

aloe, guggul, belladonna, nuxvomica, *Solanum khasiamum*, senna, plantago, stevia, coleus and acorus.

#### **Practical**

Botanical description and identification of medicinal and aromatic plants; identification of spices and plantation crops;

propagation techniques in aromatic and spice crops; selection of mother palm and seed nuts in coconut and oil palm; distillation procedures for aromatic crops; propagation methods in plantation crops (tea and coffee); propagation and planting

methods in turmeric, ginger and black pepper; harvesting procedures in aromatic plants; processing and curing of spices and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity

standards; economics of warm season vegetable crops.

### **Suggested Readings**

#### **HOR 503 Landscaping And Ornamental Gardening 3(2+1)**

##### **Theory**

###### **UNIT I**

Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, informal and free style gardens.

###### **UNIT II**

Urban landscaping, Landscaping for specific situations, institutions, industries, residences, hospitals, roadsides, traffic islands, dam sites, IT parks, corporate offices.

###### **UNIT III**

Garden plant components, arboretum, shrubbery, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers; Production technology for selected annual ornamental plants.

###### **UNIT IV**

Lawns, establishment and maintenance of vertical garden, roof garden, bog garden, sunken garden, rock garden.

###### **UNIT V**

Bio-aesthetic planning, eco-tourism, indoor gardening, xeri-scaping, hard-scaping.

##### **Practical**

Identification and selection of ornamental plants for landscaping, practices in preparing designs for home gardens, institutional gardens, avenue planting, 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.

#### **HOR 504 Breeding of Horticultural Crops**

**3(2+1)**

##### **Theory**

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection,

hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, achievements and future thrust in the following selected crops. Issue of patenting, PPVFR act.

### **Crops**

UNIT I : Mango, banana, papaya and grapes

UNIT II:, Citrus and apple

UNIT III: Potato, tomato and brinjal

UNIT IV: Hot & Sweet pepper, okra, cabbage and cauliflower

UNIT V: Rose, chrysanthemum, gladiolus and dahlia

### **Practical**

Characterization of germplasm, blossom biology, study of anthesis, 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, paleoanalogical studies, selfing and crossing techniques in horticultural crops; hybrid seed production of horticultural crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; Visit to breeding blocks.

Kaloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.

Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.

Paroda RS & Kaloo 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.

Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

Rai N & Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publ. Agency.

Ram HH. 1998. *Vegetable Breeding: Principles and Practices*. Kalyani Publ.

Ray PK. *Fruit Breeding*. Narasa Publ.

Singh BD. 1983. *Plant Breeding*. Kalyani Publ.

Singh PK, Dasgupta SK & Tripathi SK. 2004. *Hybrid Vegetable Development*. International Book Distributing Co.

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. *Advances in Citriculture*. Jagminder Book Agency.

Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

### **HOR 505 Production Technology of Cool Season Vegetable Crops**

**3(2+1)**

#### **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, knol-khol, sprouting broccoli, Brussels sprout

#### UNIT III

Root crops: carrot, radish, turnip and beetroot

#### UNIT IV

Bulb crops: onion and garlic

#### UNIT V

Peas and french bean, cool season green leafy 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 regulators and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ polyhouse.

Shanmugavelu KG. 1989. *Production Technology of Vegetable Crops*. Oxford & IBH.

Singh DK. 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.

Singh SP. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. Comm. Res. Centre.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata McGraw- Hill.

### **HOR 506 Subtropical And Temperate Fruit Production 3(2+1)**

#### **Theory**

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

#### **Crops**

UNIT I: Apple, pear and grapes

UNIT II: Plums, peach, apricot and cherries,

UNIT III: Litchi, loquat, persimmon, kiwifruit, strawberry

UNIT IV: Nuts- walnut and almond

UNIT V: Minor fruits- mangosteen, carambola, bael, fig and jamun

### **Practical**

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

## **HOR 507 Post Harvest Management Of Horticultural Crops 3(2+1)**

### **Theory**

#### UNIT I

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

#### UNIT II

Physiology and biochemistry of ripening and senescence, ethylene evolution and ethylene management, factors leading to post-harvest loss and pre-cooling.

#### UNIT III

Treatments prior to shipment, viz., chlorination, waxing, chemicals, bio-control agents and natural plant products. Methods of storage, ventilated, refrigerated, MAP, CA storage, zero energy cool chamber, hypobaric storage, spoilage: microbial and biochemical, physical injuries and storage disorders.

#### UNIT IV

Packing methods and transport, principles and methods of preservation, processing and canning. Preparation of fruit juices, beverages, pickles, jam, jellies, candies and tomato products. Value addition and post harvest management of loose and cut flowers.

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, management of processing wastes and 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.

## **HOR 508 Growth And Development of Horticultural Crops**

**3(2+1)**

### **Theory**

#### UNIT I

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in horticultural crops.

#### UNIT II

Physiology of dormancy and germination of seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinins and abscisic acid; Application of plant growth regulators, plant growth retardants and inhibitors for various purposes in horticultural crops; Role and mode of action of morphactins, anti-transpirants, anti-auxin, ripening retardant and plant stimulants in horticultural crop.

#### UNIT III

Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in horticultural crops; apical dominance.

### **Practical**

Preparation of solutions of plant growth regulators and their application; experiments in induction and breaking of dormancy by chemicals; induction of parthenocarpy and fruit ripening; application of plant growth substances for improving flower initiation, sex modification, reduce flower and fruit drops and improving fruit set in horticultural crops.

## **HOR 509 Protected Cultivation of Horticultural Crops**

**3(2 + 1)**

### **Theory**

Prospects of protected floriculture in India; Types of protected structures - Greenhouses, polyhouses, shade nets, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures - economics of cultivation; Location specific designs; Structural components; Suitable crops for protected cultivation: Strawberry, capsicum, tomato, cucumber, rose, gerbera and carnation.

#### UNIT II

Environment control - management and manipulation of temperature, light, humidity, air and CO<sub>2</sub>; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

#### UNIT III

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, de-shooting, de-blossoming, etc.); Staking and netting, Photoperiod regulation.

#### UNIT V

Harvest indices for domestic and export market: harvesting techniques.

### **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.

## **HOR 510 Canopy Management In Fruit Crops 2(1+1)**

### **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.

Spacing and utilization of land area; Canopy management through rootstock and scion, training and pruning and management practices.

#### UNIT IV

Canopy development and management in relation to growth, flowering, fruiting and fruit quality in apple, peach, pear, grapes, mango, sapota, guava 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.

## **HOR 511 Systematics of Vegetable Crops 2(1+1)**

### **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 summer vegetables (tomato, brinjal, chilli and cucumber) and winter vegetables (cauliflower, cabbage, peas and beans).

#### UNIT III

Cytology and descriptive keys of above vegetables.

#### UNIT IV

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.

### **HOR 512 Production Technologies of Cut Flowers**

**3(2+1)**

#### **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. Flower production - 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 III

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, Methods of delaying flower opening, Precooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

**Crops:** Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, dahlia, gypsophilla, statice, cut foliages and fillers.

#### **Practical**

Botanical 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.

## **HOR 513 Production Technologies For Medicinal And Aromatic Crops 3(2+1)**

### **Objective**

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

### **Theory**

#### UNIT I

Export and import status, Indian system of use of medicinal plant, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production.

#### UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera*, *Andrographis paniculata*.

#### UNIT III

Production technology for Isabgol, Poppy, Safed musli, *Stevia rebaudiana*, *Ocimum* sp.

#### UNIT IV

Post harvest handling of above mentioned medicinal plants and herbal products and phytochemical extraction techniques.

#### UNIT V

Aromatic industry, Indian perfumery industry, History, Advancements in perfume industry.

Production technology for palmarosa, lemongrass, citronella, geranium, artemisia, mentha, patchouli, lavender.

#### UNIT VII

Post-harvest handling of above mentioned aromatic crops.

### **Practical**

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important aromatic crops, Visit to distillation and value addition units.

## **M.Sc. (Ag). Courses – Mycology and Plant Pathology**

### **MPP -501 Mycology**

**3(2+1)**

### **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 III

Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi.

### 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.

## **MPP-502 Plant Virology**

**3(2+1)**

### **Theory**

UNIT I History of plant viruses, composition and structure of viruses.

UNIT II Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host-virus interaction, virus-vector relationship.

UNIT III Virus nomenclature and classification, genome organization, replication and movement of viruses.

UNIT IV Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics.

UNIT V Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultra-microtome.

UNIT VI Origin and evolution, mechanism of resistance, genetic engineering, ecology, and management of plant viruses.

### **Practical**

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratome, PCR.

**MPP-503**

**Plant Bacteriology**

**3(2+1)**

**Theory**

UNIT I History and introduction to phytopathogenic prokarya, viz., bacteria, MLOs, spiroplasmas and other fastidious prokarya. Importance of phytopathogenic bacteria.

UNIT II Evolution, classification and nomenclature of phytopathogenic prokarya and important diseases caused by them.

UNIT III Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic prokarya.

UNIT IV General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.

UNIT V Prokaryotic 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.

**MPP-504 Principles of Plant Pathology 3(3+0)**

**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.

**MPP-505 Detection And Diagnosis of Plant Diseases**

**2(0+2)**

**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, 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.

### **MPP-506 Principles of Plant Disease Management 3(2+1)**

#### **Theory**

UNIT I Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanical 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-avis 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.

### **MPP-507 Diseases of Field And Medicinal Crops 3(2+1)**

#### **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 III

Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

##### UNIT IV

Diseases of Cash crops- cotton, sugarcane.

##### UNIT V

Diseases of Fodder legume crops- berseem, oats, guar, lucerne, cowpea.

##### UNIT VI

Medicinal crops- plantago, liquorice, *mullathi*, 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.

### **MPP-508 Diseases of Fruits, Plantation And Ornamental Crops**

**3(2+1)**

#### **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 pathogens. 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.

### **MPP-509 Diseases of Vegetable And Spices Crops 3(2+1)**

#### **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.

### **MPP-510 Seed Health Technology 3(2+1)**

#### **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.

### **MPP-511 Chemicals In Plant Disease Management 3(2+1)**

#### **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, factor 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 pathogen; methods of application of chemicals.

### **MPP-512 Ecology of Soil-Borne Plant Pathogens 3(2+1)**

#### **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.

UNIT III Suppressible soils, biological control- concepts and potentialities for managing soil borne pathogens. **Practical**

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic

microorganisms. Isolation and identification of different biocontrol agents.

## **MPP-513 Disease Resistance In Plants 2(2+0)**

### **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 infectious 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.

## **MPP-514/ ENT-514 Insect Vectors of Plant Viruses And Other Pathogens 2(1+1)**

### **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.

## **MPP-515 Biological Control of Plant Diseases 3(2+1)**

### **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, antibiosis, 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* & *in vivo* conditions. Study of cfu/g.

## **MPP-516 Integrated Disease Management 3(2+1)**

### **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.

## **MPP-517 Mushroom Production Technology 3(2+1)**

### **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, CO<sub>2</sub>, ventilation in cropping rooms, cultivation technology of *Agaricus bisporus*, *Pleurotus* sp., *Calocybe indica*, *Lentinus edodes* and *Ganoderma lucidum*.

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

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.

## **MPP-518 Epidemiology And Forecasting of Plant Diseases 3(2+1)**

### **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 forecastings, 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.

## **MPP-519 Post Harvest Diseases 3( 2+1)**

### **Theory**

UNIT I Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as pre-harvest and post-harvest, merits and demerits of biological/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.

**MPP-520 /ENT-520**

**Plant Quarantine**

**2(2+0)**

## **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 II Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

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.

## **M.Sc. (Ag.) Courses-Plant Physiology**

### **PPH 501 Principles of Plant Physiology**

**4(3+1)**

#### **Theory**

#### UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

#### UNIT II

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations- cell water terminology, water potential of plant cells.

#### UNIT III

Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants - Mycorrhizal association on water uptake.

#### UNIT IV

Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration-transpiration -Driving force for transpiration, plant factors influencing transpiration rate.

#### UNIT V

Stomata structure and function - mechanism of stomatal movement, antitranspirants.

#### UNIT VI

Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

#### UNIT VII

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

#### UNIT VIII

Uptake of mineral elements in plants -Mechanisms of uptake-translocation of minerals in plants.

#### UNIT IX

Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

#### UNIT X

Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO<sub>2</sub> reduction in Calvin cycle, supplementary pathway of C fixation in C<sub>4</sub> and CAM plants and its significance.

#### UNIT XI

Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth.

#### UNIT XII

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

#### UNIT XIII

Nitrogen metabolism: Inorganic nitrogen species (N<sub>2</sub>, NO<sub>3</sub> and NH<sub>3</sub>) and their reduction to aminoacids, protein synthesis and nucleic acids.

#### Unit XIV

Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

#### UNIT XV

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominance, senescence, fruit growth, abscission.

#### UNIT XVI

Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

#### **Practical**

Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on

stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients, Radiant energy measurements, separation and quantification of chlorophylls, O<sub>2</sub> evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Estimation of reducing sugars, starch. Estimation of NO<sub>3</sub>, free aminoacids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene.

Demonstration of photoperiodic response of plants in terms of flowering.

## **PPH 502 Plant Developmental Biology Physiological And Molecular Basis 2( 2+0) Theory**

### **UNIT I**

Plant Biodiversity, Concept of evolution in plants.

### **UNIT II**

General Aspects - Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth.

### **UNIT III**

Seed Germination and Seedling Growth - Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

### **UNIT IV**

Shoot, Leaf and Root Development - Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.

### **UNIT V**

Floral Induction and Development - Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

### **UNIT VI**

Seed Development and Dormancy - Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.

### **UNIT VII**

Senescence and Programmed Cell Death (PCD) - Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

### **UNIT VIII**

Light Control of Plant Development - Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

## UNIT IX

Embryonic Pattern Formation - Maternal gene effects; Zygotic gene effects; Homeotic gene effects in *Drosophila*; Embryogenesis and early pattern formation in plants.

## UNIT X

Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize.

## UNIT XI

Special Aspects of Plant Development and Differentiation - Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants;

## UNIT XII

Self-incompatibility and its genetic control; Heterosis and apomixis.

## **PPH 503 Physiological And Molecular Responses of Plants To Abiotic Stresses**

**3(2+1)**

### **Objective**

To apprise the students regarding abiotic stress to plant and its molecular basis.

### **Theory**

#### UNIT I

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.

#### UNIT II

Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept.

#### UNIT III

Transpiration and its regulation - stomatal functions.

#### UNIT IV

Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

#### UNIT V

Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.

#### UNIT VI

Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).

#### UNIT VII

High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.

#### UNIT VIII

Chilling stress: Effects on physiological processes. Crucial role of membrane lipids.

#### UNIT IX

Salinity: Species variation in salt tolerance. Salinity effects at - Cellular and whole plant level, tolerance mechanisms. Salt tolerance in - Glycophytes and halophytes, Breeding for salt resistance.

#### UNIT X

Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

#### **Practical**

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress -stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use - efficiency, Determination at whole plant and single leaf level, Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance- Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O<sub>2</sub> evolution of chloroplasts- as a screening technique for chilling tolerance.

**PPH 504                      Hormonal Regulation of Plant Growth And Development                      3(2+1)**

#### **Theory**

#### UNIT I

Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. triconanol, Phenols -polyamines, jasmonates, Concept of death hormone.

#### UNIT II

Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.

#### UNIT III

Hormone mutants and transgenic plants in understanding role of hormones.

#### UNIT IV

Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation,

Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

#### UNIT V

Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.

#### UNIT VI

Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

#### **Practical**

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins- bioassays- GA effect on germination of dormant seeds, cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bioassay estimation using immunoassay technique. ABA effect on somatal movement, Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

### **PPH 506      Physiology of Growth And Yield And Modeling**

**2(1+1)**

#### **Theory**

##### UNIT I

Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation

##### UNIT II

Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.

##### UNIT III

Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

##### UNIT IV

Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity - partitioning efficiency and harvest index.

##### UNIT V

Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

##### UNIT VI

Plant ideotypes,

## UNIT VII

Simple physiological yield models- Duncan's, Monteith's, and Passioura's

## UNIT VIII

Crop growth models-empirical models testing and yield prediction.

### **Practical**

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters - LAD, NAR, CGR, LAI, LAR, SLA partitioning efficiency HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized, Computer applications in plant physiology, crop productivity and modeling.

## **PPH 507 Genome Organization In Higher Plants**

**3(2+1)**

### **Theory**

#### UNIT I

Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autotetraploids and polyploids.

#### UNIT II

Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokaryotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

#### UNIT III

Mitochondrial and chloroplastic genome organization and regulation of gene expression.

#### UNIT IV

Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases.

#### UNIT V

Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation ; Suppressor tRNAs.

#### UNIT IV

Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retrotransposons; Repair and recombination.

### **Practical**

Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of bacteriophage; studies on lytic and lysogenic phages.

## **PPH 508 Morphogenesis, Tissue Culture And Transformation 3(2+1)**

### **Theory**

#### UNIT I

Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation.

#### UNIT II

The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

#### UNIT III

Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country ( ovary and ovule culture , in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.

#### UNIT IV

Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) - axillary bud, shoot - tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions).

#### UNIT V

Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization - an introduction, Various methods for fusing protoplast, chemical and electrical . Use of markers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids)

#### UNIT VI

Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introduction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots vs Dicots), Root - formation using *A. rhizogenes*

### **Practical**

*In vitro* culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethylene on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single - cell suspension cultures.

## **PPH 509 Physiology of Crop Plants - Specific Case Studies**

**2(2+0)**

### **Theory**

#### UNIT I

Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance.

#### UNIT II

Crop specific topics.

### UNIT III

Seed dormancy, photoperiodic and thermoperiodic responses.

### UNIT IV

Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

## **PP 510 Physiological And Molecular Aspects Of Photosynthesis-Carbon And Nitrogen Assimilation Theory**

**3(2+1)**

### UNIT I

Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

### UNIT II

Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.

### UNIT III

Photosynthetic carbon reduction cycle and its regulation. CO<sub>2</sub> Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C<sub>4</sub>, CAM and single celled C<sub>4</sub> organisms, C<sub>3</sub>-C<sub>4</sub> intermediates. Ecological significance of CCM.

### UNIT IV

Rubisco structure, assembly and kinetics, photorespiration and its significance.

### UNIT V

Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of  $r_a$ ,  $r_s$  and  $r_m$ . Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.

### UNIT VI

Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity - transgenics. Conceptual approaches of expressing C<sub>4</sub> photosynthesis genes in C<sub>3</sub> species.

### UNIT VII

Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and non-photochemical quenching of chlorophyll fluorescence.

Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.

#### UNIT VIII

Prospects of improving photo synthetic rate and productivity - potential traits of photosynthesis- biotechnological approaches.

#### UNIT IX

Nitrogen assimilation in photosynthesizing cells - NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup> reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

#### **Practical**

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O<sub>2</sub> evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates -gas exchange. A, gs, Ci, A/gs, C/gs- intrinsic WUE by gas exchange rates. Light, CO<sub>2</sub>, VPD response curves, Determination of photorespiration by gas exchange- (TPSAPS). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH<sub>4</sub><sup>+</sup>, reduction of inorganic nitrogen species.

### **PPH 511 Mineral Nutrition 3(2+1)**

#### **Theory**

##### UNIT I

Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

##### UNIT II

Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

##### UNIT III

Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.

##### UNIT IV

Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

##### UNIT V

Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of

Phosphorous, Iron and Zinc efficient crop varieties.

#### UNIT VI

Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

#### **Practical**

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities, fertility evaluation. Methods, Soil testing - Chemical methods. Critical levels of different nutrients in soil. Plant analysis - DRIS methods, critical levels in plants. Rapid tissue tests. Indicator plants. Biological method of soil fertility evaluation. Soil test based fertilizer recommendations to crops. Factors influencing nutrient use efficiency (NUE) in respect of N, P, K, S, Fe and Zn fertilizers. Sources, method and scheduling of nutrients for different soils and crops grown under rainfed and irrigated conditions.

**Practical:** Principles of analytical Instruments and their calibration and applications, Colorimetry and flame photometry. Estimation of available N, P, K, S and Zn in soils, pH, EC, soluble cations and anions in soil water extracts. Lime requirement and gypsum requirement of problem soils. Estimation of N, P and K in plants.

## **M.Sc. (Ag.) Courses- Soil Science and Agricultural Chemistry**

### **SSC 501 Soil Physics 3(2+1) 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 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.

## UNIT X

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management. **Practical**

- Mechanical analysis by pipette and international methods
- 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

## **SSC 502**

## **Soil Fertility And Fertilizer Use**

**4 Crs. (3+1)**

### **Objective**

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

### **Theory**

#### UNIT I

Soil fertility and soil productivity; nutrient sources - 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 alkali 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; sitespecific 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**

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- .
- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for total and available nutrients
- Analysis of plants for essential elements

## **SSC 503 Soil Chemistry 3Crs. (2+1) Objective**

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

### 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; 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, ionic activity measurement, thermodynamics, anion and ligand exchange - inner- sphere 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, EC<sub>e</sub>, ESP, SAR and important relations; soil management and amendments.

### UNIT VIII

Chemistry and electrochemistry of submerged soils.

## Practical

- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC,  $E_h$  by the use of  $E_h$ -pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Potentiometric and conductometric titration of soil humic and fulvic acids
- ( $E_4/E_6$ ) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the A ( $E_4/E_6$ ) values at two pH values
- Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm
- Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved
- Determination of titratable acidity of an acid soil by  $BaCl_2$ -TEA method
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

## SSC 504 Soil Mineralogy, Genesis, Classification And Survey

3 Crs. (2+1)

### 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

Concepts and definitions of soil, soil profile; Formation and weathering of rocks and mineral, weathering sequences of minerals. Factors of soil formation, soil forming processes.

#### UNIT IV

Concept of soil individual; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy; application of soil taxonomy.

## 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.

## UNIT VI

Landform - soil relationship; major soil groups of India and UP.; land capability and 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
- Land use planning exercises using conventional and RS tools

## **SSC 505 Soil Erosion And Conservation 3(2+1)**

### **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 EI<sub>30</sub> 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 III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

#### UNIT IV

Principles of erosion control; erosion control measures - 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; socio- economic 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, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI<sub>30</sub>) using rain gauge data
- Visits to a watersheds

## **SSC 506 Soil Biology And Biochemistry 3(2+1)**

### **Theory**

#### UNIT I

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

#### UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

#### UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, basic principles of humus formation.

#### UNIT IV

Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

#### UNIT V

Preparation of farmyard manure, animal manures, rural and urban composts and vermicompost.

#### UNIT VI

Biofertilizers - Definition, classification, specifications, method of production and role in crop production.

#### **Practical**

- Determination of soil microbial population
- Soil microbial biomass
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N<sub>2</sub> fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect

### **SSC 507 Geomorphology And Geochemistry 2 (2+0)**

#### **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, trace and other human essential elements.

### **SSC 508 Radioisotopes In Soil And Plant Studies**

**2 (2+0)**

#### **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 soil & plant studies

#### 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  $^{32}\text{P}/^{65}\text{Zn}$
- Use of neutron probe for moisture determination
- Sample preparation and measurement of  $^{15}\text{N}$  enrichment by mass spectrophotometry/ emission spectrometry

**SSC 509**

**Soil, Water And Air Pollution**

**3(2+1)**

#### **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 micro- organisms.

##### 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 VIII

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 and pesticides 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
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**SSC 510 Remote Sensing And Gis Techniques For Soil, Water And Crop Studies 3(2+1)**

### **Theory**

#### UNIT I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.

#### UNIT II

Sensor systems - camera, microwaveradiometers and scanners; fundamentals of aerialphotographs 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**

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- 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 geo- statistical 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
- 

**SSC 511 Analytical Techniques And Instrumental Methods In Soil And Plant Analysis 2 (0+2)**

### **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

Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometry; identification of minerals by X-ray by different methods.

#### UNIT III

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.

## **SSC 512 System Approaches In Soil And Crop Studies**

**3(2+1)**

### **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

## **SSC 513 MANAGEMENT OF PROBLEM SOILS AND WATERS**

**3(2+1)**

### **Theory**

#### UNIT I

Area and distribution of problem soils - acidic, saline and sodic soils; origin 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; characterization of brackish waters; 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 ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$ ) in ground water and soil samples
- Determination of anions ( $\text{Cl}^-$ ,  $\text{SO}_4^-$ ,  $\text{CO}_3^-$  and  $\text{HCO}_3^-$ ) in ground waters and soil samples

Lime and gypsum requirements of acid and sodic soils

**SSC 514 Fertilizer Technology 1(1+0) 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.

**SSC 515 Land Degradation And Restoration 1(1+0)**

**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.

# **E- courses**

## **M.Sc. (Ag.) Courses**

**PGS -501**

**Library and Information Services**

**1(0+1)**

### **Objective**

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, web of Science search engines etc.) of information search.

### **Practical**

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI

Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

### **PGS -502 Technical Writing and Communications Skills 1(0+1)**

#### **Practical**

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, precis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination,

Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000;

Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout

Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National

Biological Diversity Act, 2003.

### **PGS- 503 Intellectual Property and Its Management in Agriculture (E-COURSE) 1(1+0)**

## **Theory**

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge,

trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives;

Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

## **PGS -504 Basic Concepts in Laboratory Techniques 1(0+1)**

### **Practical**

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccumets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of

solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

## **PGS -505 Agricultural Research, Research Ethics and Rural Development Programmes (e-Course) 1(1+0)**

### **Theory**

#### **UNIT- I**

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities

at national and regional levels; International fellowships for scientific mobility.

#### **UNIT- II**

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

### UNIT- III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural

### **PGS 506 Disaster Management (e-Course)**

**1(1+0)**

### **Theory**

#### UNIT -I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

#### UNIT -II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

#### UNIT -III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.