1. Agri-Business Management

Eligibility: Agri-Business Management/Rural Management/Agricultural Economics /Management.

Syllabus:

Unit-1: General Management

Introduction to management; Evolution of management thought; Management functions; Managerial roles, skills and levels; Decision making; Organizational context of decisions; Decision making models; Management by objectives; Organizational conflicts; Managing change; Leadership styles; Group dynamics. Introduction to human resource management; Human resource planning; Recruitment, placement and talent management; Training and development; Performance appraisal; Compensation; Labour relations; Dispute andgrievance handling procedures, Contemporary issues in human resource management. Nature, scope and significance of organizational behaviour; Foundations of individual behaviour; Interpersonal Behaviour; Motivation-types and theories. Information needs of organization, MIS and decision making; Applications of MIS in various functional areas of management with special reference to agribusiness.

Unit-2: Marketing and Strategic Management

Core marketing concepts; Marketing orientation; Segmentation, targeting and positioning; Consumer behaviour and brand management; Marketing mix decisions; Product life-cycle; Product mix; Pricing strategies; Services marketing; New product development; Channel management; Wholesaling and retailing; Marketing information system; Integrated marketing communications mix; International marketing; New trends in marketingpractices- digital marketing, social media marketing, societal marketing, influencer marketing, omni channel marketing. Strategic management concept and process; Types of business strategies; Tools and techniques for strategic analysis- Ansoff matrix, BCG matrix, Porter's generic strategies; Environment scanning and industry analysis-PESTEL Analysis, SWOT analysis, Competitor analysis; Porter's five forces model; Strategy formulation- Generic strategies, Turnaround strategies, Diversification strategy; Managing agricultural technologies for business- Patent, Geographic Indications, Trademark, etc.

Unit-3: Operations and Agri-Supply Chain Management

Production planning and control; Types of manufacturing systems and layouts; Process selection and facility layout; Operations strategy; Developing operations strategy; Elements of operations strategy; Competitive priorities; Manufacturing strategies; Service strategies; Productivity variables and productivity measurement; Production planning and control; Product selection; Product design and development; Process selection; Capacity planning; Inventory management and models-EOQ, JIT etc.; Purchase management; Qualityassurance; Statistical process control; Quality management- Pareto charts, TQM, Ishikawa charts, Fault tree analysis, Six Sigma; Lean Management. Supply chain-meaning and concepts; Supply chain management (SCM)- evolution, approach, elements, and conceptual model; Agri supply chain; Traditional vs modern supply chains; Demand forecasting and management in supply chain; SCM metrics and drivers; Elements of logistics; Third party logistics; Warehousing management: Distribution management and strategies; IT application in SCM-AI, Machine Learning, IoT, Remote Sensing, GPS, Blockchain, etc.; Value chain concepts and models.

Unit-4: Accounting & Financial Management

Branches of accounting-cost accounting, financial accounting, managerial accounting; Accounting concepts, principles, standards and conventions; Advantages and limitations; Double entry system; Analysis of financial statements: Ratios, time series, comparative and common size statements, DuPont analysis, cash flow and funds flow analysis; Classification of cost; Marginal costing and Cost volume profit analysis; Standard costing and variance analysis; Budget and budgetary control; Tax system-GST, MAT. Objectives and functions of financial management; Capital budgeting-types and techniques; Cost of capital; Leverage analysis; Capital structure theories; Dividend- thcory and policy; Management of working capital, receivables, cash, collections and disbursement; Investment of surplus cash; Risk and return concepts & analysis; Capital asset pricing model. Financial system in India-Banks, NBFCs, FinTech startups, Microfinance Institutions; Agribusiness financing in India; Venture capital financing.

Unit-5: Applied Agribusiness Economics

Basic economic principles; Theory of consumer behaviour, and its applications- Demand analysis; Demand function; Demand elasticity; Demand forecasting; Objectives of firms;

Production, cost and supply analysis; Pricing under different market structures- perfect and imperfect competition (monopoly, monopolistic, oligopoly), Pricing methods and strategies-product pricing and input pricing; National income; Circular flow of income: Consumption, investment and saving; Money-functions, demand & supply; Inflation; Economic growth; Business cycles.

Unit-6: Agribusiness Policies and International Trade

Role of agribusiness in Indian economy; Linkages among sub-sectors of agribusiness; Emerging trends in farm input sector, farm production, agricultural finance, agro- processing, international trade etc.; Institutional innovations-cooperatives, producer companies, private markets, contract farming, futures trading in agri commodities, e-NAM, etc. Policies and regulations - seed bill, land tenancy act, fertilizer policy, pesticides bill, APLM act, agri-export policy, agri-price policy, corporate social responsibility. Importance of foreign trade for Indian economy; Theories of international trade- absolute and comparative advantage, Terms of trade; Balance of payments; WTO and its implications; Agreement on agriculture; Tariff and non-tariff barriers, Foreign trade of India; CDMs and carbon trade; Export procedures and export documentation; Export assistance and incentivesin India.

Unit-7: Agricultural and Food Marketing

Dimension and classification of agricultural market; market-structure, conduct, performance; Market functions; Marketed and marketable surplus; Marketing efficiency; Linkages between agriculture and food industry; Marketing boards-NDDB, NFDB, Coffee Board, Spice Board, Rubber Board, etc.; Regulated markets; Cooperatives in the agriculture and food sectors; Marketing channels and strategies for different inputs (Seed, pesticide, fertilizers, feed, farm machinery, etc.) and outputs in agri and allied sector; Organic food market; Market linkages for agri-inputs and agricultural produce. Post-harvest losses in agricultural commodities; Food quality standards (AgMark); HACCP; ISO; Food labelling & packaging; Food traceability; GAP/GHP/GMP; International Food Business, market entrystrategies, managing global supply chain. Global food systems; Role of institutions and certification agencies in food marketing-APEDA, MPEDA, NPOP, India Organic, PGS India, FSSAI, NAFED, NECC, FCI, etc.

Unit-8: Marketing Research and Quantitative Techniques

Research process and types; Research design; Data collection methods; Sampling techniques, Questionnaire designing; Descriptive statistics, Bivariate analysis, Corelation, ANOVA, Multivariate statistical analysis techniques, Correlation and regression analysis, hypothesis testing, Interval estimation, Prediction in linear regression model. Principal component analysis, Linear discriminant analysis, Factor analysis, Cluster analysis, Time series econometrics; Forecasting techniques (AR, MA, ARMA and ARIMA models); Logit and Probit models; Scaling techniques, Multidimensional scaling; Conjoint analysis. Linear programming problem formulation; Graphical Method and simplex method; Transportation and assignment problems; Inventory control models; waiting line models; Decision making under risk and uncertainties; Game theory – two -person zero-sum game; Simulation; Decision trees; Pay off tables; Stochastic models, Neural networks, Markov process.

Unit-9: Project Management and Entrepreneurship Development

Project planning and formulation; Project feasibility- market feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis; Project's life cycle and network analysis -PERT & CPM; Project report preparation. Entrepreneurship theories and models; Significance of entrepreneurship in economic development; Qualities of an entrepreneur; Entrepreneurial motivating factors; Business plan formulation-importance and essential elements; Stages of start-up business; Skill development and startup ecosystem for agriculture in context of Startup India, Skill India, Make in India. Development of women entrepreneurship; Social entrepreneurship; Innovative approaches to agripreneurship; Business Incubation; Steps and procedure to start a new business; Business incubation ecosystem in NARES; Business opportUnities and challenges in different field of agriculture and allied sectors; Sources of financing; Government policy support to agripreneurs.

2. Agricultural Biotechnology

Eligibility: Molecular Biology & Biotechnology/ Bioinformatics/ Biotechnology/Agricultural Biotechnology/Genetics & Plant Breeding/Plant Breeding & Genetics/Genetics/Plant Breeding/Plant Biotechnology/Plant Molecular Biology/Genetic Engineering.

Syllabus:

Unit-1: Basic Genetics

Early concepts of inheritance, Mendel's laws of inheritance, Chromosomal theory of inheritance; multiple alleles, quantitative inheritance, gene interactions, sex determination, differentiation and sex-linkage, sex-influenced and sex-linked traits, Linkage-detection and estimation; recombination and genetic mapping in eukaryotes, heritability, heterosis or hybrid vigour, extra chromosomal inheritance. Mendelian population, random mating population, frequencies of genes and genotypes, Hardy-Weinberg equilibrium: causes of change

Unit 2: Biochemistry and Enzymology

Structure, classification, properties and function of carbohydrates, amino acids, proteins and lipids; Chemistry of nucleic acids, different forms of DNA; Structure of RNA and their classification; Structure, classification and function of plant secondary metabolites; Structure and biological functions of vitamins and coenzymes; Enzymes: classification, binding sites and catalytic sites monomeric and oligomeric enzymes, Mechanism of enzyme action; Cofactors and coenzymes in enzyme catalysed reactions, metal activated enzymes and metalloenzymes; Relationship between initial velocity and substrate concentration, Michaelis-Menten equation, Line weaver-Burk and Eadie-Hofstede plots; Allosteric enzymes and allosteric regulation. Feedback regulation; Enzyme inhibition and its uses Industrial application; Clinical applications of enzymes; Immobilization of enzymes. Bioenergetics; Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation; Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force.

Unit 3. Plant Microbe Interactions

Microbial commUnities in the soil and atmosphere; plant–microbe and microbe-microbc interactions leading to symbiotic, associative, endophytic and pathogenic interactions; Effects of microorganisms on plants: recognition processes and signal exchange; Molecular aspects of plant growth promoting rhizobacteria (PGPR); Symbiotic diazotrophs: Rhizobia and association with legumes, Mycorrhizal associations; Biocontrol agents and their action; Endophytes associations; Siderophores secretion systems of microbes and plants determining soil health, nutrient availability and uptake; Recombination in bacteria, fungi and viruses; Transformation, transduction and conjugation; Quorum sensing in bacteria; Microbiome-phytobiome dynamics; Industrial application of agriculturally important microbes.

Unit 4. Computational and Statistical tools in Biotechnology

Measures of Central Tendency, Measures of Dispcrsion, Testing of hypothesis, Exploratory Data Analysis, Binomial, Poisson and normal distributions, Level of Significance, Testing of hypothesis, Normal, t, F and Chi-square tests, Testing of multiple hypothesis, MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling, Multiple regression analysis, Likelihood approach in estimation and testing, Resampling techniques – Bootstrapping and Jack-knifing; Markov Models, Hidden Markov Models, Bayesian estimation and Gibbs sampling. Designing of experiments, characteristics of a good design, Basic principles of designs- randomization, replication and local control, Uniformity trials, size and shape of plots and blocks, Completely randomized design, randomized block design and Latin square design. Factorial experiments (symmetrical and asymmetrical). Orthogonality and partitioning of degrees of freedom. Concept of confounding, Split plot and strip plot designs, analysis of covariance andmissing plot techniques in randomized block and Latin square designs, Transformations, Balanced incomplete block design, rcsolvable designs and their applications, Lattice design, alpha design- concepts, randomization procedure, analysis and interpretation of results. Response surfaces, Combined analysis; Correlation and rcgression; Probability,

Unit 5. Bioinformatics

Bioinformatics basics, scope and importance, Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, secondary database, structural databascs–PDB, SCOP and CATH, Specialized genomic resources, Microarray database. Bioinformatics tools for Genome annotation, Genome and transcriptome sequence analysis; Sequence submission

and retrieval system-SEQUIN, BANKit, SAKURA, Webin; Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis-, CLUSTAL W, Phylip, Tcoffee. Protein secondary and 3D structure prediction. Evaluation of models- Structure validation and refinement- Ramachandran plot, Force field calculations, SAVES, Protein function prediction- sequence and domain based, Primer designing- principles and methods. Drug discovery, Structure- based Drug Design- Rationale for computer aided drug designing, docking, QSAR.

Unit 6. Molecular and Cell Biology

Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences. Central dogma of Molecular Biology; DNA replication, Models of DNA replication; Enzymes and accessory proteins and its mechanisms; Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Structure of prokaryotic and eukaryotic genes, Prokaryotic transcription, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription, Eukaryotic promoters and enhancers, Transcription factors,Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing. Genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes inprokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, transpeptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation. Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: lac and trpoperons, attenuation, anti-termination, stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix etc. Epigenetic regulations. Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major cell organelles. Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors, signalling through G-protein coupled receptors, enzyme linked receptors;

signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cellmovement; Extracellular matrix. Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular events at M phase, mitosis and cytokinesis, Extracellular and intracellular control of cell division; abnormal cell division: cancer- hall marks of cancer and role of oncogenes and tumour suppressor genes in cancer development - Programmed cell death (Apoptosis). Differentiated cells; Stem cells

Unit 7: Principles in Molecular Biology Techniques

Isolation of genomic and plasmid DNA, RNA, proteins from bacteria and plants; Isolation and restriction of plant DNA, Quantification of DNA/RNA by agarose gel electrophoresis and spectrophotometry, Principles of PCR,, Types of PCR– multiplex, nested, reverse transcriptase, touchdown PCR, hot start PCR;. Recombinant DNA construction; Restriction digestion of plasmid and phage DNA, ligation, Transformation of *E. coli* and selection of transformants. Chromatographic techniques; Dot blot analysis, Southern hybridization, Northern hybridization, Western blotting and ELISA.Radiation safety and non-radio isotopic procedure. Synthesis and cloning of cDNA. Realtime PCR; Polyacrylamide Gel electrophoresis, Protein quantification; SDS-PAGE and 2-D electrophoresis; designing RNAiconstructs; Yeast1 and 2-hybrid syatems; Generation and screening of plant mutants; Chemical, radiation and transposon mediated mutagenesis.

Unit 8: Omics and System Biology

Different methods of genome sequencing, principles of various sequencing chemistries, Concepts and methods of next generation sequencing (NGS), physical and genetic maps,Flow cytometry, PFGE, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed model genomes, *E. coli, Tobacco Mosiac Virus, Saccharomyces*, *C elegans*, *Drosophila*, Zebra fish, human, *Arabidopsis*, Rice etc. Preliminary genome data analysis, DNA sequence comparison, annotation and gene prediction. Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, Protein-basics: primary-, secondary- and tertiary structure, proteome analysis

using mass spectrometry, crystallography and NMR, Basics of software used in proteomics, MASCOT, PD-Quest, etc.; study of protein- protein interactions. Prokaryotic and yeast-based expression system and purification. Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, basics of ionomics analysis, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA). Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome. Introductory systems Biology- The biochemical models, genetic models and systems model, Molecules to Pathway, Biological oscillators, Genetic oscillators; Drosophila development; pathways to network, Gene regulation at a single cell level, Transcription network, Regulatory circuits, Negative and positive auto-regulation, Alternative stable states, Bimodal switches, Network building and analysis

Unit 9: Immunology and Molecular Diagnostics

ImmUnity and its classification; Components of innate and acquired immUnity; Lymphatic system; Haematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs; Descriptions of Antigens- immunogens, hapten and adjuvants. Immunoglobulins-basic structure, classes andsubclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signalling; Basis of self and non- self-discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cluster of differentiations (CDs); Cytokines- properties, receptors and therapeutic uses; Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex (MHC) genes, MHC, immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co- operation, Hapten-carrier system;Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques– RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Assays for assessing ligand–receptor interaction; CMI

techniques- lymphoproliferation assay, Mixed lymphocyte reaction; Cell cytotoxicity assays; Apoptosis; Active and passive immunization; Live, killed, attenuated, subUnit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric andhybrid monoclonal antibodies; ImmUnity to Infection,Bacteria, viral, fungal and parasitic infections.

Unit 10: Plant Molecular Biology

Model Systems in plant biology (*Arabidopsis,* Rice, etc.) Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear, Mitochondrial and Chloroplast Genomes. Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Virus induced gene silencing, Transcriptional Gene Silencing, Plant Developmental processes, Regulation of flowering: ABCD Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development., Plant photoreceptors and light signal transduction, vernalization, Circadian rhythms. Abiotic stress responses: Salt, cold, heat and drought. Biotic stress responses. Molecular Biology of Plant-pathogen Interactions, Molecular Biology of Rhizobium and Agrobacterium- Plantinteraction. Role of programmed cell death in development and defence.

Unit 11: Plant Tissue Culture and Micropropagation

History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; National certification and Quality management of TC plants; Genetic fidelity testing and Virus indexing methods – PCR, ELISA Micropropagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity testing; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis; Protoplast culture; Protoplast fusion; Production of somatic hybrids and Cybrids;, Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture. Large-scale cell suspension cultures - Production of alkaloids and other secondary

metabolites- techniques to enhance secondary metabolite production, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry; Somaclonal and gametoclonal variations – causes and applications; Callus culture and *in vitro* screening for stress tolerance; Artificial seeds, *In vitro* germplasm storage and cryo-preservation. Commercial tissue Culture: Case studies and success stories,Market assessment; project planning and preparation, economics, government policies

Unit 12: Gene Cloning, Plant Genetic Engineering and Genome Editing

DNA Modifying enzymes,Restriction Enzymes; Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein interactions; Salient features and uses of commonly used vectors: Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag, etc.; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Construction of cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein- protein interactive cloning and Yeast two hybrid system; Isolation of genes of economic importance; Principles in maximizing gene expression; Codon optimization for heterologous expression. Genetic transformation of plants– *Agrobacterium* mediated method. Direct DNA delivery; Promoters and Marker genes; Chloroplast transformation; Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of copy number and gene integration site; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; for quality improvement; edible vaccines; Genetic engineering for resistance against abiotic and biotic stresses; Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Cisgenesis and intragenesis; Regulated andtissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants. Genome editing for targeted genemodifications – ZFN, TALENS, CRISPR/CAS,Characterization of genome edited plants; Applications of genome editing in crop improvement.

Unit 13: Molecular Markers and Marker-Assisted Breeding

Types of molecular markers and development of sequence based molecular markers – RFLP, RAPD, AFLP, SCARs, CAPS, SSRs, SNPs, InDels, DArTseq and genic markers; Concepts of mapping, Inheritance of markers, Linkage analysis; Construction of molecular linkage map, Mapping genes for qualitative traits, Mapping populations:Development of different kinds of segregating populations– F_{2-3}, BC_1F_{1-2}, RIL, BIL, AIL, DH, NIL, NAM, MAGIC. Genotyping by sequencing and high-density chip arrays. QTL mapping using structured populations; statistical concepts in QTL mapping; Genome Wide Association Studies (GWAS),Principle of Association mapping, DART array sequencing, Illumina's Golden GateTechnology.Principles and methods of Genomic Selection, Development of gene based markers; Allele mining by TILLING and Eco-TILLING. Tagging and mapping of genes. Bulked segregant and co-segregation analysis, Fine mapping of genes/QTL; map-based of cloning genes and QTLs. Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and gene pyramiding;marker assisted recurrent selection; case studies in MAS, requirement for successful marker assisted breeding, cost of MAB. Haplotype concept and Haplotype- based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant varicty protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

Unit 14: Plant Hormones and Molecular biology of Stress Tolerance

Hormones in plant growth and development: Transport of Auxins, Induction of vascular tissues by Auxin; Hormones and the regulation of water balance, seed development and germination, Hormonal control of day length and senescence; Role of jasmonates, salicylic acids and peptide hormones in plant defense, growth, development and reproduction; NPR 1 dependent Salicylic acid signalling, PAMP and effector triggered immUnity, systemic acquired resistance and SA signalling; Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin

biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signalling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signaltransduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis,catabolism and signal transduction. Strigalactone biosynthesis, transport and signalling in plant parasitism and symbiosis. Abiotic and biotic stresses and adaptation strategies; Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress– effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants-synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; Water logging stress– effects on plant growth and metabolism; adaptation to water logging and submergence, tolerance mechanisms. Strategies for improving submergence tolerance. Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis,Strategies to improve salinity tolerance in plants. High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid development. Characters of helophytes and sciophytes – solar tracking – sieve effect and lightchannelling. Heavy metal stress – Al and Cd stress- effects on plant growth and development,biotech Strategies to overcome heavy metal stress; Nutrient stress- effects on plant growthand development. Biotic stress (insect and pathogen) resistance mechanisms. Genetic manipulation strategies to overcome the stress effects.

Unit 15: IPR, Biosafety, Bioethics and Bio-entrepreneurship

IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP; Implications of IPR on commercialization of biotechnology products, ecological implications; Trade agreements- WTO and other international agreements, Cross border movement of germplasm. Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of bio- hazard materials; Approved regulatory laboratory practices and principles; The Cartagena

Protocol on biosafety; Biosafety regulations in India; National Biosafety policy and law; Biosafety regulations and guidelines in other countries; Potential concerns of transgenicplants– Environmental safety, food and feed safety; Safety assessment of transgenic plants in India– sequential steps in risk assessment; Concepts of familiarity and substantial equivalence; Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; toxicity and allergenicity; Monitoring strategies and methods for detecting transgenics; Field trials for Biosafety assessment– standard operating procedures; Labelling of GM food; Bio-ethics: mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labelling of GM food and crop; Biopiracy; Types of bio-industries – bio-pharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bio-entrepreneurship – Biotechnology on a global scale; Skills required for successful entrepreneur; OpportUnitiesfor bio-entrepreneurship; Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India); Business plan preparation;business feasibility analysis by SWOT, socio-economic cost-benefit analysis; Statutory and legal requirements for starting a company/venture; Entry and exit strategy; Identifying needs of customers; Market linkages, branding issues; Developing distribution channels- franchising; promotion, advertising; branding and market linkages for 'virtual start-up company'; Pricing strategy; Knowledge Centres e.g. Universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer.

3. Agricultural Chemicals

Eligibility: Agricultural Chemicals/Agricultural Chemistry/Chemistry.

Syllabus:

Unit-1: General Chemistry

Oxidation states and chemical reactivity; Acid-base chemistry; Chemical bonding; Chemical kinetics; Enzyme kinetics, Thermodynamics; Surface Chemistry; Colligative properties of solutions; Ionic equilibria; Solubility product; pH and buffer solutions; Colloids and suspensions; Redox reactions; Stereochemistry – chirality, isomerism, conformation and configuration; Chemistry of aliphatic, aromatic and important heterocyclic compounds (furan, thiophene, pyrrole, pyrazole, imidazole, oxazole, thiazole, pyridine, piperidine, quinoline, isoquinoline), important chemical reactions and their mechanisms (electrophilic and nucleophilic substitution reactions, elimination reactions, addition reactions); Pericyclic reactions; Organic name reactions(Diels Alder reaction, Grignard reaction, Aldol condensation, Perkin reaction, Benzoin condensation, Friedel Craft alkylation and acylation reaction, Fries rearrangement, Reformatsky reaction, Wittig Reaction, Sandmeyer reaction, Oppenaeur oxidation, Ziegler Natta reaction); Photochemistry.

Unit 2: Advanced Laboratory and spectroscopy Techniques

Laboratory hygiene and safety; Handling and storage of hazardous chemicals; Safety practices in chemical laboratory; Techniques of distillation and drying of solvents; Common extraction and separation techniques; electrophoresis; Basic principles and applications of chromatographic techniques - TLC, preparative TLC, HPTLC, paper chromatography, column chromatography, gas chromatography, liquid chromatography, gel permeation chromatography, super critical fluid chromatograph, ion exchange chromatography; Basic principles and applications of spectroscopic techniques – UV, visible, IR, NMR, mass;Tandem GC-MS and LC-MS techniques.

Unit 3: Chemistry of Natural Products

Chemistry of carbohydrates, amino acids, proteins and nucleic acids, polysaccharides, fats, lipids, vitamins, terpenoids, carotenoids, flavonoids, alkaloids and steroids; Chemistry of natural polymers (Starch, cellulose, agar, inulin, chitosan, alginate, dextran, guar gum, gum Arabic, gum tragacanth,xanthan gum, pectin) Metabolomics approach for profiling of secondary metabolites; Natural antioxidants and food colorants (carotene, lycopene,

betanaine, capsanthins, capsicinoids, anthocyanins, curcuminoids); nutraceuticals and phytoceuticals, functions and bioavailability; Enzymes.

Unit 4: Agrochemicals for Insect, Mite and Termite Management

History, classification, chemistry and mode of action of insecticides (organochlorines, organophosphates, carbamates, synthetic pyrethroids, neonicotinoids, insect growth regulators, newly discovered insecticide molecules); Acaricides; Termiticides; Molluscicides; Rodenticides; Insecticide Resistance and its Management.

Unit 5: Agrochemicals for Disease and nematode Management

History, classification, chemistry and mode of action of fungicides (inorganics, dithiocarbamates, heterocyclics, organophosphates, strobilurins, miscellaneous); Chemical Control of Plant Parasitic Nematodes - properties and uses of Chemical Nematicides; Fungicide Resistance and its Management;

Unit 6: Agrochemicals for Weed and Crop Management

History, classification, chemistry and mode of action of herbicides (aliphatics, aromatics, carbamates, phenyl ureas, triazines, diphenyl ethers, dinitroanilines, amides, sulfonyl ureas, heterocyclics, bipyridiliums); Herbicide safeners; Plant growth regulators – auxins, gibberellins, cytokinins, ethyelene, abscisic acid, brassinolides, etc.; Resistance of chemical herbicides and their management

Unit 5: Chemistry of Biopesticides

Isolation, characterization, chemistry and mode of action of botanical pesticides (pyrethrins, rotenones, nicotine, azadirachtiniods, toosendanin, ryanodine, rocaglamides, annonins, isobutylamides, quassinoids, and sugar esters from plant sources, plant essential oils); Insect behavior modifying chemicals (juvenile hormones, moulting hormones, pheromones, semiochemicals, allelochemicals – allomones, kairomones, synomones, apneumones, Phytoalexins); Insect feeding deterrents and repellents; Microbial insecticides, fungicides and herbicides; Entomopathogenic nematodes, fungi, and plant inhabiting fungal endophytes; Application of biotechnology in pest management – recombinant DNA technology, genetically modified crops.

Unit 6: Agrochemical Formulations

Basic concepts of pesticide formulation – classification, solid and liquid formulations, preparation, physico-chemical properties and uses; Adjuvants in formulation - carriers,

diluents, surfactants, emulsifiers, dispersing agent, wetting agents, stickers and spreaders, penetrants, safeners, encapsulants, synergists, antioxidants, stabilizers etc.; Controlled release formulations; New generation pesticide formulations; Pesticide application and delivery systems - principles, distribution and coverage; Application of nanotechnology in pesticide formulation - nanoemulsions, nanodispersions, nanoencapsulation, and other polymer based formulations, nanocarriers for targeted and controlled release, benefits and environmental risks of nanopesticides.

Unit 7: Pesticide Residues and their Dynamics in the Environment

Pesticide residue – concept and significance; Sampling, sample processing and testing; Different extraction and clean up techniques for optimum recovery; Method development; Validation and performance verification through linearity, sensitivity, matrix effect, limit of quantification (LOQ), limit of detection (LOD), accuracy and precision of recovery; Measurement uncertainty (MU); Monitoring of pesticide residue in agricultural produce and environment by QuEChERS, ELISA, Radiotracer techniques; Multiresidue analysis; Consumer risk assessment and MRL fixation of pesticides in food commodities; Translocation of pesticides in the plant, soil and aquatic environment; Metabolism of pesticides and xenobiotics – biotic and abiotic transformations, microbial degradation; Persistence and dissipation of pesticides and xenobiotics in the environment

Unit 8: Agrochemicals – Regulations and Quality Control

Production, consumption, and trade statistics of agrochemicals; Banned and restricted pesticides; Pesticide registration – laws, acts, rules governing production, use and regulations; The Insecticides Act (1968) and Rules (1971); Food Safety Standard Act (2006) and Rules (2011); Pesticide Management Bill; Pesticide registration in India; National and international guidelines for safe use of pesticides – WHO, FAO, CAC, EPA; Sanitary and phytosanitary measures; Quality assurance and quality control in pesticide analysis; General criteria for accreditation of chemical and food laboratories, integrated pest and pesticide management

Unit 9: Agrochemical pollution Management

Pesticide hazards and environmental pollution, effect of pesticide on soil health, persistent organic pollutants, adverse effect of industrial effluents on soil and aquatic environment, disposal of obsolete and outdated pesticides, physical, chemical, microbial decontamination, bioremediation and detoxification of xenobiotics, Fertilizers, biofertilizers, nitrification

inhibitors, controlled release products, hydrogels and their application in agriculture, soil conditioners,

Unit 10: Data analysis

Method of statistical analysis as applied to agricultural data- standard deviation, standard error, accuracy, precision, analysis of variance (ANOVA), correlation and regression, chi- square, F-test, probit analysis

4. Agricultural Economics

Eligibility: Ph.D. in Agricultural Economics/Dairy Economics/Veterinary Economics/Livestock Economics/Fisheries Economics/Economics.

Syllabus:

Unit-1: Economic theory

Theory of consumer behaviour; utility maximization; demand models; demand elasticity; consumer welfare and its measurements; theory of firms and market structures; price determination under different markets- perfect competition, monopoly, monopolistic competition, and oligopoly; price discrimination; effect of taxation under different market conditions; labour and land markets; game theory- concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies; general equilibrium theory; welfare economics - concepts, problems, approaches and limitations of welfare economics, pareto conditions of maximum welfare – criteria for social welfare - social welfare functions, social versus private costs and benefits. Conceptual frameworks of Classical, Keynesian, Neo-Classical, and Neo-Keynesian macroeconomics; aggregate demand and supply in closed and open economy-determination of wages, prices, output and employment; national income accounting; theories of aggregate saving and investment; theory of business cycle-alternative equilibrium models; functions and demand for money; exchange rate determination; balance of payment; inflation; income and interest determination; IS-LM functions; monetary and fiscal policies; international financial markets, deficit financing.

Unit-2: Agriculture development and institutional economics

Role of agriculture in economic growth and development; sources of agricultural growth and development; emerging challenges in economic growth and sustainable agricultural development; poverty and inequality; growth models: Harrod-Domar, Neo-Classical, Rostow's growth stages, Lewis-fei-Ranis model, induced innovation model, Mahalanobis model, input-output model; five-year plans and agriculture; features of planning in capitalists, socialist and mixed economies; role of agriculture and allied sectors in Sustainable Development Goals (SDGs) and progress. Innovations in institutions- agri-startups, FPOs, Custom Hiring Centres (CHCs), etc; Distinction between institutions and organizations– institutional evolution; Market failure- information asymmetry, Principal-

Agent problems, moral hazards; Group and Collective action- The logic of collective action and its role, theory of Groups, Free rider problem, path dependency, Interlinked transactions. Rent seeking- interest groups and policy formulation. Theories of agrarian institutions.

Unit-3: Agricultural production economics

Basic principles of farm management; farm planning and budgeting; different types of production functions- assumptions, properties, estimation and their economic interpretation; analytical approaches to economic optimum; decision making with multiple inputs and outputs; cost functions; principles and importance of duality theory; correspondence of production, cost, and profit functions; duality theory; derivation of supply and factor demand functions from production and profit functions; optimization of resource allocation, resource-use efficiency and returns to scale, frontier production function; total factor productivity; yield gap analysis- types and measurement, nature and sources of risk –modeling and coping strategies; decision making under risk and uncertainties; technological changes in crops, livestock & fisheries sectors.

Unit-4: Agricultural finance and project analysis

Principles and functions of agricultural finance; agricultural credit- sources and forms, cost of credit, credit appraisal-3 Rs, 3 Cs and 7 Ps of credit, estimation of credit requirement; Financial institutions related to agriculture and rural development. reforms in agricultural credit policy; financial system in India-commercial banks, cooperatives, RRBs, micro-finance institutions (MFI); International financial institutions; innovations in agricultural financing. Project identification, project life cycle, social cost-benefit analysis; SWOC analysis; project risk analysis; project scheduling and resource allocation; financial, economic and environmental appraisal of investment projects; choice of discount rate, - net present value (NPV), internal rate of return (IRR), benefit-cost ratio (BCR); network analysis –PERT & CPM; analysis of financial statements-balance sheet, income statement cash flow statement; financial ratios; risks in agriculture; Risk management strategies and coping mechanism; crop and livestock insurance programmes.

Unit-5: Agricultural marketing and trade

Agricultural marketing system in India; marketing functions; marketing channels- price spread and efficiency; structure, conduct and performance analysis; market integration and

price transmission - supply / value chain management; multi market estimation; price forecasting models- techniques and applications, construction of price indices and market performance indices. role of information technology and market intelligence in agricultural marketing. Agricultural commodity marketing -spot and futures- marketing of derivatives speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets-regulatory mechanism of futures trading. Government interventions including administrated price policy; buffer stock operations; price stabilization measures and policies; market reforms; marketing institutions-role and functions; e-NAM, contract farming; status of market infrastructure. International trade in agriculture: Competitive and comparative advantage, trade theories; trade policies- export promotion and import substitution policies; tariff and non-tariff barriers; models and agreements; regulations and reforms for marketing and trade, WTO, SPS measures and competitiveness; ecological concerns and marketing ethics.

Unit-6: Natural resources management and environmental economics

Natural resources - meaning, characteristics, and classification; stock dynamics of renewable and non-renewable resources; property rights in natural resources and their implication for conservation and management of natural resources; management of commonproperty natural resources – institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource; resource scarcity–natural resourcedegradation – poverty and resource degradation; pricing and valuation of natural resources; Transboundary environmental issues - economics of global warming, climate change and emission trading; environmental externalities of current agricultural practices; economic growth and environmental cost - growth oriented economic policies and their environmental impacts; sustainable development– issues and indicators of sustainable development; environmental cost benefit analysis- environmental impact assessment techniques; non-market valuation of environmental resources; environmental pollution as a consequence of market failure; economics of pollution – private vs. social cost; theory of environmental policy; basic approaches to environmental policy (Tax, subsidy, pollution permits, etc.); concepts of ecosystem services and its application in managing natural resources.

Unit-7: Research methods and econometrics

Objective, types and process of research; research hypothesis- meaning, types, setting; hypothesis testing- parametric and non-parametric tests; sampling methods- probabilistic and non-probabilistic; sample size determination; sampling and non-sampling errors;

measures of central tendency, measures of variation, skewness and kurtosis; Scaling techniques; ANOVA; correlation and regression, discriminant and dummy variable analysis; OLS, generalized least squares, MLE, logit and probit models- assumptions, properties, and estimation; simultaneous equation methods –identification – estimation by indirect least squares 2SLS, PIML, SURE, 3SLS; autoregressive distributed lag models – panel data fixed and random effects models; multivariate analysis- cluster analysis, factor analysis; principal component analysis.

Unit-8: Agricultural policy analysis

Linear programming (LP)-objective, assumptions, formulation; primal and dual LP problems; recursive programming, dynamic programming; transportation and assignment problem. Simulation and programming techniques in agricultural production- Multiple Objective Programming (MOP), goal programming, compromise programming; MOTAD; Supply response models. Instruments of agricultural policy; process of agricultural policy formulation and implementation; legal and anthropological challenges for formulating and enacting agricultural policies; review of existing agricultural policies- land policy- water policy – credit policy – input and product marketing policy – price policy; recent government initiatives in crop, livestock and fisheries sectors; agrarian structure and land reforms; agricultural R&D and linkages; intellectual property rights and its role in agricultural R&D; impact assessment techniques- economic surplus method, PSM, DID, synthetic control method, randomize control trials (RCT), etc. and its applications; applications of behavioral economics for agriculture and food policy analysis; demand and supply analysis for policy making; outlook models; Social Accounting Matrices and multipliers - computable general equilibrium models to assess economy-wide impact of policy changes; approaches for improving food & nutritional security and environmental sustainability.

5. Agricultural Entomology

Eligibility: Ph.D. in Entomology/Agricultural Entomology/Zoology.

Syllabus:

Unit-1: Systematics

History and development of Entomology, Evolution of insects, position of insects in the animal world, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important FamilDetailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography. Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times. Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories – requirements and procedures. Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular systematics.Multivariate analysis for clustering of specimens; rooting & character polarisation for developing cladograms; use of computer programs for development of cladograms.

Unit-2: Morphology

Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and

venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders. immatures stages: types ecological and evolutionary adaptation.

Unit-3: Embryology, internal anatony and physiology

Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function and physiology of Digestive, Circulatory, Respiratory, Reproductive, Nervous and Excretory systems, Sense Organs; structure and types. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets. Biosynthesis of chitin, chitin protein interactions, Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms. Physiology of endocrine system, role of endosymbionts, biochemistry and MOA of behaviour modifying chemicals. Defence mechanism in plants against insects.

Unit- 4: Ecology

Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, population dynamics, distribution and dispersal. Principle of biogeography and insects biodiversity. Biotic potential and environmental resistance. Ecosystems, agroecosystems analysis, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasite interactions, ecological niche. Life table studies, population models. Food chain and food web. Arthropod population monitoring, pest forecasting. Diapause and causes of pest out breaks.

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

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

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

Conservation, reproductive ecology, evolution of herbivory, stress ecology.

Unit-5: Biological control

Importance and scope of biological control, history of biological control: Biocontrol agents-parasites, predators and insect pathogens. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests. Entomophilic pathogens: bacterial, fungi, viruses, rickettsiae, Protozoan and nematodes, Modes of transmission, methods of uses, symptoms of infection. 4 Microbial insecticides and their formulation. Merits and demerits of microbial control. Role of biocontrol agents and microbial insecticides in Integrated Pest Management. Nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-à-vis target pest populations.

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

Risk analysis in augmentative biological control; evaluation of BC programs- analysis and feasibility; risk assessment of natural enemies in BC; habitat manipulation for suppression of populations; role of endophytes and endosymbionts in BC; resistance to microbial pathogens

Unit- 6: Chemical control and toxicology

History, scope and principles of chemical control. Insecticides and their classification. Formulations of insecticides. Susceptibility of insects to the entry of insecticides. Physical,

chemical and toxicological properties of different groups of insecticides: chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, chlordimeform, chitin synthesis inhibitors, avermectins, nitroguandines, phenylpyrrozzoles, botanicals (natural pyrethroids, rotenone, neem products, nicotine, pongamia spp. etc). Combination insecticides. Problems of pesticide hazards and environmental pollution. Safe use of pesticides, precautions and first aid treatments. Insecticides Act 1968, registration and quality control of insecticides. Evaluation of toxicity, methods of toxicity testing, determination of LD 50, LT 50, RL 50 etc. Pesticides residues in the environment and their dynamics of movements, methods of residue. Pharmacology of insect poisons. Mode of action of different groups of insecticides; neuroactive (axonal and synaptic) poisons, respiratory poisons, chitin synthesis inhibitors. Metabolism of insecticides; activative and degradative metabolism, detoxification enzymes and their role in metabolism. Selectivity of insecticidal actions; insecticide resistance; mechanism, genetics and management of insecticide resistance.

Penetration and distribution of insecticides in insect systems; developments in bio-rational approaches; SPLAT; RNAi technology for pest management. Biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.Insecticide laws and standards and pesticide bill

Unit-7: Host plant resistance

Chemical ecology: mechano and chemo receptors. Host plant selection by phytophagous insects. Secondary plant substances and their defenses against phytophagous insect. Basis of resistance (Antixenosis, Antobiosis, Tolerance). Biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Breeding for insect resistant plant varieties. Resistance development and evaluation techniques. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

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

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

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

Unit-8: Innovative approaches in pest control

Behavioral control: pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Potentialities of IPM.

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

Unit-2: Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

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

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

Unit-9: Integrated pest management

History, concept and principles of IPM. Components of IPM: Host plant resistance, agronomic manipulations, mechanical and physical methods, chemical methods, biocontrol agents utilization, genetic and behavioral control strategy etc. IPM strategies for field and horticultural crops. IPM case histories. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. System approach, Agro ecosystem and cropping system vs. IPM. Constraints and Strategies of IPM implementation.

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

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

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

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management. Protective cultivation, climate change and IPM, global role and risk of invasive pests

Unit-10: Pesticide application equipment

Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Power operated sprayers and dusters. Types of nozzles and their uses. Maintenance of appliances. Aerial application of pesticides, principles of aerial application, factors affecting the effectiveness of aerial application. Equipments for aerial applications. Advantages and disadvantages of aerial application.

Release of bio-control agents; Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers; • Uses of light, transmission and scanning electron microscopy; • Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE; • Use of tissue culture techniques in plant protection; • Computer application for predicting/ forecasting pest attack and identification.

Unit-11: Pest of field crops and their management

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy catepillars, cut worms and white grubs.

Insect pest scenario in relation to climate change non-insect pests (mites, birds, rodents, snails, slugs, etc.

Unit-12: Pest of horticultural crops and their management

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits and plantation crops, spices, condiments andornamentals. Management of Forest insect pests needs to be added

Unit-13: Pests of stored products and their management

Fundamentals of storage of grains and grain products. Storage losses, sources of infestation/infection, factors influencing losses, insect and non-insect pests, their nature of damage and control. Microflora in storage environment and their control. Storage structures, bulk storage and bag storage, their relative efficacy and demerits. Grain drying methods and aeration. Non-insect pests (rodents, birds, mites) of stored products and their control. Integrated management of storage pests.

Introduction, history of storage entomology, conccpts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-à-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

Unit-14: Arthropod vectors of plant diseases

Common arthropod vectors viz., aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psylids, beetles, weevils, flies, bees and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission : Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases.

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 insectvectors. Efficiency of transmission

Unit-15: Honey bees and beekeeping

Honey bees and their economic importance. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal management. Bee enemies including diseases and their control.

Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages

Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.

Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

Non-Apis pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

Unit-16: Silkworms and sericulture

Silkworm species, their systematic position and salient features. Rearing techniques of mulberry-muga-eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltism and moultism, seed production and its economics. Enemies and diseases of silkworms and their management. Sericulture organization in India.

History of Sericulture, importance, distribution, area and silk production

Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture

Unit-17: Lac Insect

Lac insect, its biology, habit and habitats. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control.

History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of broodpreserving. Host-specific technologies – cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio-economic potential of lac; export-importof lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

Other useful insects

Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Usefulness of insects in scientific investigations, insects as food.

Edible and therapeutic insects: the concept, definition, and importance. History and origin of insects as food, feed and medication; important insect species and insect products consumed. Edible insect ecology, conservation and management of edible insect resources; environmental opportUnities of insect rearing. Nutritional composition and role of insects in food security. Unit V Insect farming: the concept, definitions, and rearing techniques. Processing edible insects for food and feed.Food safety and preservation, edible insects for livelihood security

Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae). Mosquito taxonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis. Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox;

mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus. Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance

Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status. History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecologicalinteractions. Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles. Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous vs exotic species; pest problems in monocultures vs mixed plantations. Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics. Insect pests in plantations: Location- specific case studies.

Unit-18: Statistics and computer application

Frequency distribution, mean, mode and median. Standard, normal, bionomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi- square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, Completely r andomized block design, Latin square design, Split-plot designs. Probit analysis. Use of soft ware packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

6. Agricultural Extension

Eligibility: Ph.D. in Agricultural Extension Education/Agricultural Extension/Agricultural Extension and Communication/Extension Education/Veterinary Extension/Dairy Extension/Fisheries Extension/Agricultural Communication/Home Science/Community Science.

Syllabus:

Unit-1: Fundamentals of Extension Education, Communication and Diffusion of innovations

Genesis and evolution of extension in India and worldwide; Extension Education and Advisory Services- concepts and principles. Extension approaches for sustainable development in agriculture, veterinary & animal husbandry, fisheries and commUnity sciencedriven livelihoods systems in India and other countries; National Agricultural Extension System and Reforms; Public extension systems – ATMA and KVK; National Mission on Agricultural Extension and Technology; Private extension system; Pluralism in extension; Farming System Research & Extension; Agricultural Knowledge and Information system (AKIS); Farmers Field School; participatory technology development; Technology assessment and refinement; Agricultural, Veterinary & Animal Husbandry, Dairy, Fisheries, and Rural Development Programmes implemented by Govt. of India; Basic rural institutions; social structure; culture and norms; Social change processes; Group dynamics. Communication- Concepts, functions, elements, process, models, theories, types, skills, problems and barriers; Social networks in communication; Development communication- need, concept, component, theories, and scope in India. Diffusion of Innovations- concept, elements, models, and theories; Innovation development process; Adoption- concept, process, models, adopter categories and their characteristics; Factors influencing adoption; diffusion network-opinion leadership, models of communication flows; communication network analysis and theories; Change agents; Innovation-decision process, Innovations in organization; consequences of innovations; reinvention, grassroots innovations; Enabling innovation.

Unit-2: Extension Methods, ICT & Educational Technology

Concepts of Andragogy and pedagogy; Human behavioural dimensions in extension - Behaviorism, Cognitivism, Constructivism; factors influencing human behaviour; Types of learning; domains of learning-cognitive, affective and psychomotor; Learning theories; Experiential learning; Concepts and elements of teaching and learning processes, principles

of learning; Cone of Experience; Classification and features of extension methods; Selection, planning and use of extension methods. Agricultural journalism- concept and theories; types of publications; basics of writing, editing, readability- Gunning Fog Index. Fundamentals of layout and design, Preparation of radio/video script. Photo-journalism; Journalistic ethics. Information and Communication Technology (ICT) -concepts and application in extension and advisory services, ICT tools- print and electronic media, commUnity radio, Social media-features and applications; Websites, portals, Expert system,and Apps related to agriculture, dairy, veterinary, fishery, and marketing, etc. m-Learning, e-learning; e-Learning platforms – MOOCs, OER, etc. Digital agriculture- applications of Artificial Intelligence (AI), IoT, GIS, GPS, Block Chain Technology; Big data analytics in extension. Educational and instructional technology - concepts, models and theories; Creating instruction; planning, designing and implementing the curricula and learning experiences; needs analysis, task and content analysis, learner analysis; Instructional techniques and strategies- Program Instruction Techniques, organizing content and learning activities; Multi-media learning-concepts, theories and models; Approaches to interactive design.

Unit-3: Research Methodology in Extension Education

Meaning of research and theory; Types of research; Stages of social research; Research problems and problem statements, Stating and testing of hypothesis; Meaning and types of variables; operational definitions; Meaning, principles, elements and criteria of research design; MAXMINCON Principle; Types of research designs; Threats to internal and external validity; Measurement – meaning, postulates and levels of measurement; Reliability and validity of instruments; Sampling designs -Probability and non-probability sampling; determination of sample size; factors affecting choice of sampling designs; Sampling and Non-sampling errors, biases; Methods of observation- Interviews, sociometry, semantic differential, Q methodology, projective techniques; focus group discussion; participant and non-participant observation; Scaling techniques-Classical test theory and item response theory; methods of scale construction; scalogram analysis, multi- dimensional scaling; use of factor analysis in scale development; development of knowledgetest; Methods of constructing

indexes; Qualitative research - ethnographic, grounded theory, Phenomenological, Behavioural modeling, Nudge theory, Content analysis discourse analysis, narrative research; Parametric and non-parametric statistics for data analysis in social research; Social Network Analysis; Multi-criteria methods; Research report writing; Ethics in extension research.

Unit-4: Extension Management and Organizational Behaviour

Meaning, concept, theories and principles of administration and management; Functions of management - planning, organizing, staffing, directing and leading, controlling, coordinating, reporting and budgeting; Decision making; Leadership styles and theories; Delegation and decentralization; Organizational Structure; Organizational Design; Organizational Communication; Organizational Culture vs. Climate; Characteristics of Organizational Culture, Creating and Maintaining Organizational Culture; Organizational Change, Organizational learning and Transformation; Motivational Theories & Techniques; Work motivation; Performance appraisal, Job satisfaction and morale; Time management; Problem Solving Techniques / Negotiation; Individual and group behaviour in organization; Team building process; Organizational development; Interventions for organizational development; Managing Stress, conflict and Emotions; Creativity- concept and process.

Unit-5: Training and capacity development

Training – Concept and types; Training Need Assessment – Concept, Methods and Process; Type of need assessment; Training Process - different phases of training; models of training; Designing training curriculum, Training strategies- Academic Strategy, Laboratory Strategy, Activity strategy, Personal development strategy, Organisational development strategy; Training Methods – Lecture, Discussion, syndicate, seminars, Panel Discussion, Conference, Symposium, Role Play, Case Study, Brain storming, Programmed Instruction, T – Group/ Laboratory methods; Factors Determining Selection of Methods; Evaluation of training; Need and principles of capacity development; process of capacity development; levels of capacity- individual, organization, enabling environment; Human resource development-manpower planning, Role analysis, Role Efficacy, Induction, training, Job enrichment, self-learning mechanisms, counselling, mentorship, Performance appraisal and feedback.

Unit-6: Technology Commercialization, Incubation and Entrepreneurship Development

Technology transfer vs commercialization; Technology commercialization process and approaches; Technology incubation- meaning, type, functions and process; Technology scouting; National IPR Policy; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Right Act (2001). Entrepreneurship- concepts, characteristics, and theories; Entrepreneurial Characteristics and Motives; Entrepreneurial competencies;Entrepreneurial motivation; Simulation games and exercises for developing entrepreneurial competencies; Entrepreneurship development cycle ; Entrepreneurial environment; barriers to entrepreneurship; forms of business ownership; Elements of project formulation- feasibility analysis, techno-economic analysis, project design and network analysis, input analysis, finance analysis, social-cost benefit analysis, project appraisal. Enterprise management-management skills, production management, financial management; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Market Intelligence, Marketing communication and promotional strategies; Life cycles of new business, environmental factors affecting success of a new business. Government policy for small scale enterprises and women entrepreneurship development; National Policy on Skill Development; Start-up India, Make in India, Digital India, Atal Innovation Mission and others; Government support and services for entrepreneurship denvelopment in agriculture, dairy, fisheries and commUnity science. Corporate SocialResponsibility, Venture Capital Fund for entrepreneurship in agriculture, dairy, and fisheries; Social entrepreneurship.

Unit-7: Program development, evaluation and impact assessment

Program planning and development-concepts and steps; Logic framework approach (LFA); Program Evaluation - concept, objectives, principles, criteria, and theories. Difference between monitoring and evaluation; Evaluation process; Steps in Programme evaluation; Types of Evaluation: Objective Oriented, Management Oriented; Context Evaluation, Input evaluation, Process Evaluation, Product Evaluation, Consumer oriented evaluation, Expertise Oriented Evaluation, Adversary Oriented Evaluation, Naturalistic and Principal oriented evaluation, goal free evaluation and meta evaluation; Levels of Bennett's hierarchy; Evaluation models; Programme management techniques; SWOT analysis, Bar Charts, Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. Defining

impact, Social Impact Assessment –stages and approaches; Theories of change; Criteria and indicators, Quantitative and qualitative techniques for impact assessment;

Unit-8: Developmental Policies, Strategies and Issues in Extension

Importance of extension policies; Role of extension in influencing policies; Policy advocacy strategy and approaches; Policy analysis- types, process, methods and techniques. New approaches and domains of extension- demand-driven extension, market-led extension(value chain extension),farmers-led extension, group-led extension, gender sensitive extension; roles and approaches of extension for enhancing capacity for climate change adaptation; promotion of conservation agriculture, nutri-sensitive agriculture, agri- preneurship, agri-tourism, and urban and peri-urban agriculture; Extension through public private partnership (PPP); Changing role of extension in the context of globalization and IPR; Extension and Sustainable Development Goals (SDGs); Sustainable rural livelihood

Unit-9: Gender Sensitization and Empowerment

Concepts of Gender- gender roles, gender equality, gender equity; gender relations, gender balance, gender bias, gender blindness, gender needs- practical and strategic, issues in agriculture and extension; Gender mainstreaming- approaches and methods; gender analysis framework and tools; Gender empowerment measures; dimensions and methodologies for empowerment; gender impact assessment; gender budgeting; gender specific technologies; gender dimensions in food and nutritional security; Women's empowerment- principles, framework and dimensions; Strategies and barriers for women empowerment; empowerment through SHG, financial inclusion, micro-finance, internet and education; women entrepreneurship; Public-Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women rights, constitutional provisions; Global and National policies and mission for empowerment of women; Government programmes and schemes for women, children and youth.

7. Agricultural Meteorology

Eligibility- Ph.D. in Agricultural Meteorology/Agricultural Physics/Physics/Environmental Sciences/Water Science and Technology/Meteorology/Atmospheric Sciences/Climate Sciences.

Syllabus:

Unit 1 : General Meteorology

Solar radiation and laws of radiation; Atmospheric and astronomical factors affecting variation of solar radiation; Greenhouse effect, albedo and heat balance of the earth and atmosphere; Ozone hole; Direct and diffuse radiation; Heat transfer: convection, conduction and radiation; Concepts of latent and sensible heat; Radiant flux and flux density; Gas laws and laws of thermodynamics and their application to atmosphere; Hydrostatic equation and its application; Pressure systems; Pressure gradient and Coriolis force; Geostrophic, gradient and cyclostrophic winds; General circulation of the atmosphere, turbulence, vorticity, atmospheric waves; Cyclones and anticyclonic motions: trough, ridge and col; Vapour pressure deficit, psychrometry, entropy, tephigram; Humidity parameters and their interrelationships; Thermal conductivity and diffusivity; Dry and moist adiabatic lapse rate, atmospheric stability and instability conditions; Clouds-their description and classification; Condensation and precipitation processes; Convectional, orographic and cyclonic precipitation; Bergeron-Findeison theory; Artificial rain making; Thunderstorms and dust storm, hail, haze, mist, fog, frost and dew; Air masses and fronts; Tropical and extratropical cyclones; Land and sea breezes; Mountain and valley breezes and other localwinds; Agromet observatory, weather variables and their measurement.

Unit 2 : General Climatology

Elements of weather and climate; Earth's rotation and seasonal distribution of radiation, rainfall, temperature, pressure belts and wind; Climatic classification - Koppen and Thornthwaite; Climatic indices; Agroclimatic zones and agroecological regions of India; Trade winds and equatorial trough and its movement; Indian monsoon and its seasonal aspects; Branches of monsoon, onset, advancement and retreat of monsoon in India; Monsoon trough; Low pressure area, monsoon depressions and their frequency and life span; Factors influencing rainfalldistribution, cyclones and cyclonic tracks over the Indian region; North western

disturbances and monsoon breaks; Heat and cold waves; Continental, maritime and monsoon climates; El-Niño, La Nina, Southern Oscillation Index, Indian OceanDipole and their impact on Indian monsoon.

Unit 3 : Agricultural Meteorology

Meaning and scope; Importance of meteorological parameters in agriculture; Thermoperiodism, photoperiodism, cardinal temperatures; Effect of thermal environment on growth and yield of crops; Thermal indices and phenology of crops; Heat Unit concept and its application; Length of growing period determination; Solar radiation and crop growth; Crop weather calendars, Agroclimatic requirement of major field crops, horticultural crops and agroforestry; Rhizosphere, microorganisms, fertilizer and water use in relation to weather; Influence of weather and climatic parameters on incidence and development of crop pests and diseases, animal and poultry diseases; Bioclimatic indices affecting human comfort, climatic normalfor animal production.

Unit 4 : Micrometeorology

Meaning and scope of micrometeorology; Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and free convection; Boundary layer, frictional effects, roughness length and zero plane displacement; unstable and inversion layers, Richardson number, Reynolds analogy, exchange coefficients; Microclimate under irrigated and rainfed conditions; Micrometeorology of field crops, orchards and forests; Absorbed and intercepted PAR; PAR distribution in plant canopies and interception as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use efficiency; wind, temperature, humidity, vapour pressure and CO_2 profiles in short and tall crop canopies; influence of topography, shelterbelts and wind breaks on microclimate, microclimate within forests, meteorological conditions in artificial and controlled climates- green, plastic, glass, poultry and animal houses and storage barns; Remote sensing application in relation to micrometeorology.

Unit 5: Hydrometeorology

Hydrological cycle and concept of water balance, Precipitation indices, climatic water budgeting and its applications; energy concept of soil water; Concepts of

evaporation, evapotranspiration, potential and actual evapotranspiration, consumptive use; Different approaches of ET determination: empirical methods, energy balance and Bowen's ratio methods, water balance single and multilayeredsoil methods, aerodynamic, eddy correlation and combination approaches, field lysimetric approaches, canopy temperature based methods and ET estimation through remote sensing; Advantages and limitations of different methods; Moisture adequacy index and their application; Rainfall-runoff relationship, measurement of runoff rate and volume; Drought and its classification, drought indices and their application under Indian condition; Advective energy determination and its effect on water use by crops; Irrigation scheduling based on climatological approaches; Water production functions.

Unit 6 : Crop Weather Modeling

Application and uses of crop weather models; Types of models; General features of statistical and dynamical modeling techniques; Crop weather analysis models, empirical-statistical models and crop growth simulation models for yield assessment; Use of dynamic crop simulation models (DSSAT, Infocrop, APSIM, Oryza, CropSyst etc.); Minimum data set for crop simulation models; Forecasting models for insects and diseases, calibration and validation of models and their application in short-term and long term climate change effect predictions, advantages and limitations of crop growth models; GIS applications for modelling and characterization of agroclimatic elements.

Unit 7 : Weather Forecasting and Weather Risk Management

Weather forecasting : scope and importance; Short, medium and long range weather forecasting; Monsoon onset and rainfall forecasts; Special forecast for natural calamities; Use of satellite cloud imageries in weather forecasting; Synoptic charts and synoptic approach to weather forecasting, use of medium, long range forecasting; Vegetative indices based agrometeorological forecasts for monitoring crop prospects and crop yield; Meteorological satellites for weather forecasts; Early warning systems for agriculture operation forecasts; Weather and climate related risks in agricultural production; Preparedness and coping strategies to meteorological disasters and hazards; Weather hazard modification for agriculture: advances inartificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of

severe storms and electric behavior of clouds; weather based advisories, contingency planning for different weather risks and aberrations.

Unit 8 : Climate change and sustainable development

Climate change and global warming: causes, future projections and consequences on hydrological cycle, monsoon, crops and various systems in relation to agriculture; Sensitivity, adaptation capacity and vulnerability assessment to climate change, climate variability and extreme weather events; National and regional scenarios of climate changeand variability, observed and predicted trends and impacts; Adaptation and mitigation strategies for climate change and sustainable development; International protocols and treaties on climate change issues, carbon sequestration, carbon credit, clean development mechanism (CDM), crop management options, land use change, forestry mechanism, alternate energy sources; Use of remote sensing in climate system observations and climate change adaptation.

Unit 9. Remote sensing and GIS in Agrometeorology

Basic components of remote sensing; Active and passive remote sensing; Characteristics of electromagnetic radiation and its interaction with matter; Spectral features of earth's surface features; Remote sensors in visible, infrared and microwave regions; Resolution of sensors; sensor platforms, their launching and maintenance. Drone technology; Data acquisition, preprocessing, storage and dissemination; Digital image processing and information extraction; Microwave remote sensing; Applications of GIS and GPS; Digital techniques for crop discrimination and identification; Use of satellite data in weather forecasting; Remote sensing applications to crop stress detection, crop yield forecasting and insect-pest development and prediction, flood and drought monitoring; Remote sensing and GIS in soil resource inventory, land use/land cover mapping and planning; Satellite climate data.

Unit 10: Air Pollution Meteorology

Natural versus polluted atmosphere; Real time air quality index and national air quality index; Sources of air pollution, classification and properties of air pollutants; Importance of anthropogenic sources; photochemical smog, trace gases, acid rain; Principles of diffusion of particulate matter in the atmosphere; Meteorological factors in the dispersion of air pollutants; Planetary Boundary Layer(PBL) and mixing layer; Meteorological conditions and plume forms; Air pollution forecasting – Gaussian diffusion models, Numerical dispersion models: Air quality standards; effect of air

pollution on biological organisms, ozone layer depletion; Air pollution control technologies; Air pollution laws and standards; Scales of air pollution- local, urban, regional, continental and global. Air pollution sampling and measurement.

Unit 11 : Livestock and fisheries meteorology

Thermal balance and the need for maintenance of thermal balance in animals; Effects of weather on animal production: loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders. Environmental modification within the shelters of livestock to reduce climate impacts; Applications of biometeorological information for management of livestock's environment; Animal diseases, parasites, poultry diseases and its relation with weather and thermal comfort. Livestock production and climate change, Management of livestock to reduce greenhouse gas emission; Weather and water temperature effect on fish activities, behavior and population; Climate change and fisheries production.

8. Agricultural Microbiology

Eligibility: Ph.D. in Agricultural Microbiology/Microbiology/Soil Science/Soil Science and Agricultural Chemistry/Environmental Science.

Syllabus:

Unit-1: Principles & Techniques in Microbiology

Scope and History of Microbiology - Evolutionary link of prokaryotes - Current classification and diversity of bacteria, Photosynthetic eubacteria - characteristics and importance; Phylogenetic classification; Groups of microorganisms – structure, function and their importance - Gram Positive and Gram-Negative bacteria – Archaea – characteristics; Staining and Microscopy - Light microscopy, Phase contrast, Fluorescent, SEM, TEM, AFM, CLSM; Sterilization and Control of microorganisms - Methods of sterilization used in microbiology laboratory - Principles and methods,Mechanical removal and filtration techniques for microbes, Physical control including radiations, Chemical control including antibiotics and chemotherapeutics, Biological control methods; Isolation, enumeration, and detection of microorganisms by phenotypic, biochemical, lipid profile and molecular methods; Determination of microbial numbers, microbial biomass by biochemical, physiological approaches (FAME); Microbial population assessment: Direct microscopic counts, plate counts, MPN methods; other indirect methods.

Instrumentation in Microbiology: Spectroscopy (Electromagnetic spectrum, Applications of Beer- Lambert law, UV-VIS spectrophotometry, IR spectroscopy, FTIR, AAS, ICPS, Flame emission spectroscopy), chromatography (classification of chromatographic methods, Column Chromatography, Gas chromatography, HPLC, ion chromatography), GC-MS, LC-MS, Elemental analysis (C, H, N, S and O), X-ray analytical methods. Flow cytometry and viable cell counts; Principles of PCR; types (Nested PCR; touchdown PCR; hot start PCR; multiplex PCR; reverse transcriptase PCR; quantitative PCR) and their relevance in identification of microorganisms, quantification, delineation of taxonomic and functional commUnities. PCR-based fingerprintingmethods: ARDRA, RISA, ERIC Fingerprints; Electrophoresis- Principles, types (vertical and horizontal; agarose, PAGE, capillary electrophoresis) and applications in microbiome analysis (DGGE, SSCP, T-RFLP, ALH-PCR).

Unit-2: Microbial Physiology, Growth and Metabolism

Laws of Thermodynamics – Bioenergetics – Microbial nutrition – Chemical composition of microbial cell – Structure, function and assembly of cell membrane in prokaryotes, archaea andfungi – Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane; Microbial growth – cell cycle & division - Factors affecting growth – Modes of growth - Morphogenesis and cellular differentiation; Enzyme- structure, classification, mechanismof enzyme reaction - Enzyme kinetics: Michaelis Menten kinetics - mechanisms of inhibition of enzyme activity - coenzymes and prosthetic groups; Definition and basic concepts of metabolism, catabolism and anabolism, microbial metabolic diversity and fuelling reactions in different microbialnutritional groups, Anabolic reactions for synthesis of macromolecules in microbes, Bacterial cell wall synthesis; Metabolic pathways - carbohydrate utilization via EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis - Mechanisms of carbon-dioxide fixation in prokaryotes; Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds Regulation of microbial metabolism. Transporters and their significance.

Unit-3: Microbial Genetics and Gene Regulation

Microbial genetics – History and major scientific contributions; Nucleic acid – overview DNA, RNA - Structure of DNA; Forms and kinds of DNA; RNA- tRNA, mRNA, rRNA; Role and replication of DNA and RNA; Bacterial genome Eukaryotic genome; Viral genome; Difference between prokaryotic and eukaryotic genome. Enzymes associated with DNA; Gene structure and expression, principles of operon, gene expression in prokaryote and eukaryotes, intron and exons, post transcriptional modifications; Regulation of gene expression, negative expression (*lac* operon and *trp* operon), positive regulation (cAMP); Mutation in bacteria: Types, effects; physical, chemical and biological mutagens; Selection of mutants; DNA damage and repair; Genetic recombination in bacteria - transformation, transduction and conjugation; Gene cloning and gene sequencing; Types of cloning vectors, Impact of gene cloning on human welfare.

Regulation of gene expression- types; Prokaryotes vs Eukaryotes; Operon concept; Next generation sequencing methods: Principles and limitations.

Unit -4 Soil Microbiology

Scope of soil microbiology - Groups of soil microflora and diversity – unculturables - factors affecting soil microbial activity - soil microbial ecology- Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance; Degradation of organic matter - Biochemical composition and biodegradation

of soil organic matter and crop residues; Biogeochemical cycling – Microbial transformation of various nutrients - C, N, S, P, Fe and Mn, Microbial interactions, Organic matter decomposition, soil enzymes, soil fertility; BNF – biochemistry and genetics; Siderophores and antimicrobials; Microbial dissolution and Biochemistry of N, P, K, Si, Ca, Mg and Zn in soil.

Interaction among the soil microorganisms: Positive and negative interactions and their ecological significances; Major microbial indicators of soil health and their significance, Soil microbial biomass, soil enzyme activities; Direct and indirect methods of studying soil microorganisms and their activities: RISA, TGGE, DGGE, T-RFLP, AFLP, BIOLOG, PLFA. Metagenome analysis of soil microbiome.

Unit -5: Applications of microorganisms in agriculture

Biofertilizers, PGPRs, Biocontrol agents: Scope in agricultural sustainability - types; Direct and indirect beneficial effects of inoculants in agriculture; Production and quality control of Biofertilizers, PGPR, bioinoculants – Effective Microorganisms; Endophytic microorganisms - ; Microbial associations in phyllosphere, rhizosphere, spermosphere; Mycorrhizae - various interfaces of interaction and role in phosphate mobilization ; Potassium releasing bacteria; Microbial management of Soil health and soil quality - microbial indicators; Microbes in biotic and abiotic stress management – Microbes in climate smart agriculture; Mitigation of abiotic/biotic stress, GreenHouse Gases – mechanisms; Reclamation of problem soils using microorganisms. Microbial commUnities in the soil - CommUnity dynamics - population interaction - Quorum sensing– flow of signals and signaling; genomics and proteomics; Biocontrol agents and their mechanism of action including SAR & ISR; Silage making; Inoculants for decomposition – Biomineralizers; Formulations, quality control and application of inoculants - Recent trends - FCO norms and BIS standards.

Unit-6: Microbiology of Food and Water

Importance and significance of microorganisms in food - Intrinsic and extrinsic factors influencing microbial growth in foods - Food spoilage – principles and its control; Microbial spoilage of meat, milk, fruits, vegetables and their products; Food borne infections and intoxications; Microbiology of water, Sources and types of water, Procedures for water purification, Water pollution and its sources, Nuisance bacteria in water, Water-borne disease, Sewage treatment, Biological oxygen demand, Effluent management, Sewage systems, Biofilms and bioflocs in wastewater treatments; Water quality and its maintenance.

Perspectives on food quality and safety, Microbiological quality assurance, Specification and standards of different foods, advanced techniques in detecting food-borne pathogens and toxins;

Food fermentations - Fermented vegetables, milk products, meat and fish; Physical methods, chemical preservatives and natural antimicrobial compounds; Biological preservation systems; Foods for Specified Health Probiotic bacteria; Bacteriocins and their applications; Pre-, probiotics and synbiotics; Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety Biocatalysts and applications - GAP, HACCP, CODEX, FSSAI - Food safety regulations.

Unit-7: Microbial Biotechnology and Industrial applications

Theory and principles of industrial fermentation; Fermentation – different types – Modes of fermentation – Batch, Continuous, Fed-batch. Microbial culture selection, Strain development, The formation and extraction of fermentation product; Fermentor design, Different types of fermentors used in industrial fermentation, Fermentations – types and modes of fermentation – Strain improvement; Media for microbial fermentation: criteria in media formulation; Media formulation and optimization; Fermentor – design consideration and types; Fermentation kinetics; mass and energy transfer in bioreactors - Instrumentation and control, containment in fermentation – fermenter preparation and use - aeration and agitation – biosensors; Downstreaming and recovery of end products.

Alcoholic beverage production - Ethanol, Beer, Wine and Cider fermentation. Microbial enzymes, their production- Rennet, Cellulase, Amylase etc., Immobilization of enzymes; microbial production of antibiotics, organic acids, amino acids, enzymes, bioplastics, biopolymers, biosurfactants, microbial colourants – Single cell proteins; Recent developments in Synthetic Biology, Pathway engineering, Process Engineering, Post translational modifications

Unit-8: Environmental Microbiology and Biofuels

Microorganisms and their natural habitats – Extremophiles – Aeromicrobiology - Environmental Distribution and Taxonomic Diversity, Physiology, Adaptive mechanisms

Microbiology and use of micro-organisms in waste treatment; Treatment schemes of domestic waste and industrial effluents; food, feed and energy; Water purification and wastewater demand, Effluent management, Sewage systems, Biofilms and bioflocs in wastewater treatments; Water quality and its maintenance.

Perspectives on food quality and safety, Microbiological quality assurance, Specification and standards of different foods, advanced techniques in detecting food-borne pathogens and toxins; Food fermentations - Fermented vegetables, milk products, meat and fish; Physical methods,

chemical preservatives and natural antimicrobial compounds; Biological preservation systems; Foods for Specified Health Probiotic bacteria; Bacteriocins and their applications; Pre-, probiotics and synbiotics; Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety Biocatalysts and applications - GAP, HACCP, CODEX, FSSAI - Food safety regulations.

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Unit-10: Environmental Microbiology and Biofuels

Microorganisms and their natural habitats – Extremophiles – Aeromicrobiology - Environmental Distribution and Taxonomic Diversity, Physiology, Adaptive mechanisms. Microbiology and use of micro-organisms in waste treatment; Treatment schemes of domestic waste and industrial effluents; food, feed and energy; Water purification and wastewater treatment -microbial biofilm and wastewater treatment - aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.); anaerobic processes. Composting of solid wastes, organic pollutant treatment; Anaerobic digestion – Biomethane production and upgradation – Bioremediation and Bioaugmentation - Biomining - Microbial metal leaching; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents, etc - Biodegradable plastics and superbugs. Energy from solid waste; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; Second generation biofuels,

biodegradation of lignin and cellulose – biodiesel and algae-based fuels.

Unit-11: Plant Microbe Interactions

Types of interactions- mode, nature, and partners; Elicitation of plant metabolic machinery; Legume-Rhizobium, Actinorhizal and other types of symbioses, mutualisms, associations with members of various Kingdoms; Signaling mechanisms- biochemical and molecular aspects; Quorum-sensing and bacterial communication, Role of QS during kinds of plant-Microbe interactions, Microbial secretion systems. Rhizosphere, Rhizoplane, Rhizosphere effect, Spermosphere, phyllosphere, endophytes, Leaf and Root exudates and their role in plant-microbe interactions; Metabolomics and their significance in plant-microbe interactions. Rhizosphere engineering: Concept and applications; Plant holobiont and its significance in agriculture; Major ecological habitats; plant-soil-water-biota interactions

Unit-12: Microbial Genomics and Metabolomics or Omics tools in Microbiology

Concept of holobiome and microbiome; Genome sequencing – Phylogeny; Microbial Population genomics CommUnities-Phylogeography; Accessing and analyzing microbial genome data.

Metagenomic, transcriptomics, metabolomics, meta-proteomics and functional genomics; Sequencing tools-algorithms-computational methods for microbial genomics; Metabolic engineeringand Microbiome engineering.

9. Agricultural Physics

Eligibility- Ph.D. in Agricultural Physics/Physics/Biophysics/Agricultural Meteorology/Soil Science/Environmental Sciences/Geo-informatics.

Syllabus:

Unit-1: Basic Physics

Conservation of mass, energy and momentum; Forces in nature; Measurement of heat, specific heat, transfer of heat; Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; Optics theory, principles of optical instruments; Change of phase and polarization, equation of state, laws of thermodynamics; free energy, entropy and concept of negative entropy; Vant Hoff's law; Basics of electromagnetic spectrum and its interaction with matter; Laws of radiation, scattering, reflection, transmission, absorption, emission, diffuse and specular radiations; radiation Units,flux, intensity, emittance, inter conversion of radiometric Units; energy balance of landsurfaces. Cathode rays; radio activity, alpha-, beta-, and gamma- rays, detection and measurement of radiation; properties of X-rays; Bragg's law; nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power.

Unit-2: Soil Physics

Factors and processes of soil formation; physical, physicochemical and biological properties of soils; soil water retention and movement under saturated and unsaturated conditions; Soil aeration; Thermal properties of soil and heat transport; Influence of soil water, temperature and aeration on crop growth and their management; Soil erosion and control; Soil physical constraints and their management, Soil physical properties; texture, mass-volume relationship, soil structure, aggregation, porosity, pore size distribution; Vector calculus, Fourier series, Numerical approximations, Monte Carlo simulation. Poiseuille's and Darcy's equations, Laplace equation of steady flow and poisson equation , hydraulic conductivity and fluxes, specific storage coefficient, aquifer transmissivity, conductance coefficient, effective hydraulic conductivity; Woodings equation for steady infiltration, Preferential flow: Measurement of saturated and unsaturated hydraulic conductivity: lab and field method, Infiltration models: Empirical models-Kostiakov model, Horton model, Physical models: green-ampt and Philip models, Solute transport: solute transport mechanisms: mass flow, diffusion, hydrodynamic dispersion, miscible and immiscible displacement, hypothetical,

Convective: diffusive equation (CDE),heat transport, thermal conductivity, thermal diffusivity; Vries method, Darcy's law for advective transport of gases, Fick's law, Dusty Gas model, Stefan Maxwell equation, Gas permeability.

Unit-3: Applied Soil Physics

Soil quality: quality assessment, indices of soil quality, least limiting water range; Proctor compaction test, soil erodibility indices; Management of problems of major soil types and their amelioration, role of tillage for modification of soil structure; Assessment of site-specific tillage, conservation tillage, effect of tillage on water and solute transport in soil; Water soluble conditioners and soil hydrogels, hydrothermal regimes; Surface soil moisture estimation by thermal and passive microwave techniques.

Unit-4: Atmospheric physics

Weather and climate: Atmosphere and its constituents; Heat balance of the earth and atmosphere; Climatic classification systems; climatology of India, agro- ecological regions; monsoon, western disturbances, cyclones, Wind system, precipitation, cloud, pressure patter; Atmospheric stability; El Nino, La Nina and ENSO; Climate change, global warming, impacts of climate change on agro-ecosystems; Physiological response of crop plants to weather (light, temperature, CO2, moisture and solar radiation); Heat Units, thermal time and thermal use-efficiency and their applications; Eddy covariance techniques; Wind profile; Modification of microclimate; Radiation distribution within plant canopy.

Unit-5: Crop micrometerology

Micro, meso and macro climates, exchange of mass, momentum and energy between surface and overlaying atmosphere, exchange coefficients, Richardson number & Reynold's analogy, Mixing length theory, boundary layer equations, surface layer, Ekman layer, frictional affects, eddy diffusion, forced & free convection. Wind profile near the ground; roughness and zero plane displacement, Windbreaks and shelter belts; Micrometeorology of plant canopies; Influence of topography on microclimate; variation in microclimate under irrigatedand rainfed conditions; Hydrological cycle and concept of water balance, concepts of evaporation, evapotranspiration, potential, reference and actual evapotranspiration, consumptive, Bowen's ratio methods, water use efficiency/water productivity, Advective energy determination, Physiological variation in relation to crop growth and development.

Unit-6: Plant Biophysics and Nano Technology

Introduction and scope of biophysics; structure and properties of water; Experimental techniques used for separation and characterization of biomolecules sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography; Fibre physics; Basic Spectroscopic techniques, UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction; chlorophyll fluorescence; Nanostructures, properties and characterization of nano materials; Nano-biology, hazards of nanomaterial; Applications of nanotechnology in agriculture.

Unit-7: Remote sensing, Satellite Agrometrology and Image processing

Electromagnetic radiation, and interactions with the matter, remote sensing system – active and passive, sensor and platform; Radiometric quantities; Spectral signatures, spectral indices; Satellite characteristics, spatial, spectral, radiometric and temporal resolutions; Air borne remote sensing; Imaging and non-imaging systems; Multispectral, hyperspectral, thermal and microwave remote sensing; Digital image processing;, National and International satellite systems for land, weather, ocean and other observations; Image processing display systems. Initial statistical extraction, Prc-processing, Image reduction, image magnification, contrast enhancement; Arithmetic operations'-based image transforms, Fourier transforms, Image compression fundamentals and models, Elements of information theory, Image segmentation, Global processes via Hough transform; Advance classification techniques: Imaging Spectroscopy, Data Processing techniques, data mining techniques, Spectral angle mapping, Spectral unmixing, Construction and application digital terrain models (DTMs), preparation of orthoimages; Satellites:geostationary and polar orbiting, international and national satellite systems and their payloads; Retrieval of cloud type and structure in visible and infrared regions, estimation of rainfall by visible; Retrieval of land surface emissivity andtemperature, global radiation, Retrieval of surface soil moisture by thermal and passive microwave, retrieval of crop biophysical parameters by empirical and physical techniques, Vegetation phenology and dynamics, Drought monitoring, modeling net primary productivityof agro ecosystems, Sensing strategies: remote airborne satellite, airplane, UAV; Proximal mobile, earthbound: Continuous moving, stationary towers probes in soil and crop. Criteria for selecting sensors: Spatial sampling, temporal resolution Data processing, Sensors for Environmental Monitoring, Soil sensors, Soil biota, geoelectrical sensors, Gamma ray soil sensing, Plant sensors.

Unit-8: Geoinformatics

Basic concepts and principles: hardware and software requirements; Common terminologies of geographic information system (GIS); Maps and projections, principles of cartography; Basic geodesy: Geiod /Datum/Ellipsoid; Cartographic projections, coordinate systems, types and scales; Accuracy of maps; Raster and vector data model; DBMS; Geostatistical analyses; Spatial interpolation-Thiessen polygon; Inverse square distance; Digital Elevation Model; Principles of GPS; DGPS; Errors in GPS data and correction; GPS constellations; Geoinformatics application in agriculture, and natural resource management; Classical methods of interpolation, spatial variability of soil properties: spatial dependence and spatial structure studies, kriging for interpolation, precision farming.

Unit-9: Mathematical Modelling of soil-plant-atmosphere system

Applications of matrices: differentiation and integration; Numerical modelling: finite difference and finite element; Spatial statistics: variogram and interpolation techniques; Surface modelling; Root water uptake models; Simulation models for water, heat, and solute movement in two and three dimensional porous media; Fundamentals of dynamic simulation, systems, models and simulation; Mechanistic, stochastic and deterministic models; Model calibration, validation and sensitivity analysis; Crop weather models and its use in crop yield estimation.

Unit-10: Physics of soil and water conservation

Soil erosion, physics of soil erosion by water, soil erodibility and indices; factors affecting soil erodibility, soil physical characteristics, land management, crop management; empirical constants, Rainfall erosivity; estimation of rainfall erosivity, Runoff measurements:current meters, flumes, weirs and orifice, stage level recorder, hydrographs; Runoff estimation: quantities and rates of runoff, rational formula, Cook's method; Sediment measurement multiplot divisor, Coshocton wheel sampler, point and depth integrated sediment samplers; Universal soil loss equation; estimation of soil loss and its prediction; Physics of wind erosion:wind velocity, initiation and movement of soil particles; Saltation, suspension and surface creep; Soil physical properties affecting wind erosion; Nonagricultural land:use of mechanical structures and biological methods; Wind erosion control. Watershed development and management.

10. Agricultural Statistics

Eligibility: Ph.D. in Agricultural Statistics/Statistics/Applied Statistics/ Biostatistics/ Mathematical Statistics.

Syllabus:

Unit-1: Probability and Mathematical Statistics: Elements of measure theory, Borel field, Probability measure; Random variable, Axiomatic approach to probability; Laws of addition and multiplication; Bayes' theorem. Discrete and continuous variables; Mathematical expectation; Mathematical expectation of functions of random variables; Moment generating function, Characteristic function; Raw and central moments. Functions of random variables; Distribution function and its properties. Univariate and bivariate probability distributions; Conditional and marginal distributions; Independence of random variables; Transformation of random variables. Cauchy-Sehwarz inequality, Jensen inequality, Markov inequality. Chebyshev's inequality; Bernoulli weak law of large numbers; Kolmogorov strong law of large numbers; Central limit theorem; Demoviere-Laplace central limit theorem. Bernoulli, Binomial, Poisson, Negative binomial, Geometric, Hypergeometric and Uniform distributions. Rectangular, Normal, Exponential, Gamma, Beta, Cauchy and Lognormal distributions. Bivariate normal distribution. Probability distributions of functions of random variables. Exponential Family of distributions, Family of Pearson distributions. Mean and variance of above mentioned distributions. Sampling distributions; Distribution of mean, difference between two means and correlation coefficient; Central t, F and chi-square distributions, their properties and interrelationships; Variance stabilizing transformations. Correlation and Regression. Multiple and partial correlation coefficients; Order statistics; Distribution of rth order statistic; Joint distribution of several order statistics and their functions; Distribution of range and median.

Unit-2: Statistical Inference: Point estimation: Mean square error; Unbiasedness, Consistency, Sufficiency, Completeness; Neyman factorization theorem with application; Minimum variance unbiased estimator; Cramer Rao inequality; Rao Blackwell theorem. Methods of estimation: Method of moments, Method of minimum chi-square, Method of maximum likelihood, their properties and applications. Confidence interval estimation for parameters of Normal, Exponential, Binomial and Poisson distributions. Testing of hypothesis; Neyman Pearson lemma; Unbiased test; Uniformly most powerful unbiased tests and their constructions. One and two-sample tests about mean, variance, proportion, simple

correlation coefficient and simple regression coefficient; Behrens-Fisher problem; Bartlett's chi-square test; Likelihood ratio test and its asymptotic properties. Chi-square tests of goodness of fit and independence. Non-parametric tests, Robust statistics, One and two-sample sign and Wilcoxon sign rank tests, run test for randomness, Wilcoxon-Mann-Whitney U test, Kruskal-Wallis and Friedman's tests, Kendall's coefficient of concordance. Elements of sequential analysis; Wald's sequential probability ratio test.

Unit-3: Applied Multivariate Analysis: Concept of random vector, Expectation operator, Dispersion matrix, Marginal and joint distribution, Conditional distribution and Independence of random vectors. Multinomial distribution. Multivariate normal distribution, Marginal and conditional distributions. Sample mean vector and its distribution; Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypotheses about mean vector. Wishart distribution and its properties; Hotelling's T2 and Mahalanobis' D2 statistics; Null distribution of Hotelling's T2. Multivariate analysis of variance; Wilk's lambda criterion and its properties; Discriminant analysis, Computation of linear discriminant function (LDF), Classification between two multivariate normal populations based upon LDF and Mahalanobis' D2. Canonical correlations; Factor analysis; Principal component analysis; Principal coordinate analysis; Cluster analysis, Similarities and Dissimilarities, Hierarchical clustering, Single and complete linkage methods. Path analysis and computation of path coefficients; Multi-dimensional scaling; Hierarchical and non- hierarchical clustering algorithm.

Unit-4: Design of Experiments: Theory of linear estimation; Gauss Markoff theorem; Aitkin's transformation; Hypothesis testing and analysis of variance; Analysis of covariance; Restricted estimation; Random, fixed, mixed effects models and Generalized Linear Model. Basic principles of design of experiments; Orthogonality; Contrast, Mutually orthogonal contrasts. Completely randomized, Randomized complete block and Latin square designs; Missing plot technique; Orthogonal and mutually orthogonal Latin squares; Graeco Latin square designs. Balanced incomplete block (BIB) designs, General properties, Analysis without and with recovery of intra-block information, Construction of BIB designs; Partially balanced incomplete block (PBIB) designs with two associate classes, General properties; Lattice designs; Alpha designs; Cyclic designs; Augmented designs; General analysis of block designs; Youden square designs; Cross-over designs. Factorial experiments, Confounding in 2^n and 3^n factorial experiments, Partial and total confounding; Fractional factorial designs for symmetrical factorials. Asymmetrical factorials. Split-plot and strip-plot designs. Combined analysis of experiments. Designs for fitting first order and second order

response surfaces, Second order rotatable designs. Multiple comparison procedures; Sampling in field experiments.

Unit-5: Sample Surveys: Complete survey vs sample survey; Probability sampling vs purposive sampling; Sampling error; Sample space, Sampling design, Sampling strategy; Confidence interval. Simple random sampling with and without replacement, Estimation of population mean and population proportion; Inverse sampling; Stratified random sampling, Optimum allocation, Number of strata, Construction of strata boundaries, Collapsing ofstrata. Determination of sample size. Ratio, regression and product methods of estimation; Separate and combined ratio estimators; Cluster sampling; Multi-stage sampling with equal probability of selection of Units at each stage; Two-phase sampling; Successive sampling over two occasions. Sampling with varying probability with and without replacement, Probability proportional to size sampling - Cumulative method and Lahiri's method of selection; Horvitz Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran; Inclusion probability proportional to size sampling. Systematic sampling; Probability proportional to size systematic sampling. Non-sampling errors, sources and classification, Non-response in surveys; Response error, Interpenetrating sub-samples, Imputation methods; Warner's randomized response technique.

Unit-6: Statistical Genetics: Physical basis of inheritance, Segregation and Linkage; Analysis of segregation, Detection and estimation of linkage for qualitative characters; Amount of information about linkage; Combined estimation, Disturbed segregation. Gene and genotypic frequencies; Random mating; Hardy-Weinberg law of equilibrium; Disequilibrium due to linkage for two pairs of genes and sex-linked genes; Forces affecting gene frequency; Equilibrium between forces in large populations, Polymorphism; Fisher's fundamental theorem of natural selection; Random genetic drift; Effect of finite population size. Polygenic system for quantitative characters; Average effect of gene; Average effect of gene substitution; Dominance deviation; Breeding value; Epistatic interaction deviation; Genotype- environment correlation, genotype-environment interaction and its application; Multiple allelism in continuous variations; Maternal effects; Different components of genetic variance and their partitioning; Effect of inbreeding on quantitative characters; Heterosis; Inbreeding depression; Effect of inbreeding on mean and variance of quantitative characters. Resemblance between relatives; Phenotypic and genetic covariance between different relatives; Concept and estimation of genetic parameters; Heritability, Repeatability and Genetic correlation; Response due to selection, Selection index and its applications in plant and animal genetic improvement programmes; Correlated response to selection; Restricted

selection index. Mating designs; North Carolina designs and their analysis; Line × Tester Analysis; Diallel and partial diallel crosses including their construction and analysis.

Unit-7: Applied Regression Analysis: Simple and multiple linear regression models and their analysis; Estimation and testing of regression parameters, Sub-hypothesis testing, Restricted estimation; Polynomial regression: Use of orthogonal polynomials. Use of dummy variables. Regression with ordinal data. Logistic regression. Selection of variables, Stepwise and Stagewise regressions. Regression diagnostics; Adequacy and validation of models. Examination of residuals - specification error, auto-correlation, Durbin-Watson statistic, Heteroscedasticity, Multi-collinearity. Weighted Least Squares, Outliers, Influential observations. Remedial measures - regression under non-normal errors, transformation of data, Generalized least squares, Model over-fitting, model under-fitting. Parameter estimation in non-linear models. Components of time-series. Fitting of different trend models. Auto-correlation and Partial Auto-Correlation functions. Correlogram. Determination of cyclical variations. Periodogram analysis. Linear Stationary models - Auto-Regressive, moving average and mixed processes. Linear non-stationary models. Forecasting. Simultaneous equation models. Indirect Least Squares. Pooling of cross-section and time-series data. Demand and Supply curves. Determination of demand curves from market data. Engel's curves. Poreto curves.

Unit-8: Mathematical Methods in Statistics and Optimization Techniques: Limit and continuity; Differentiation of functions, Successive differentiation, Partial differentiation. Mean value theorems, Taylor and Maclaurin's series; Integration of rational, irrational and trignometric functions. Differential equations of first order, Linear differential equations of higher order with constant coefficients. Simple interpolation; Divided differences; Numerical differentiation and integration. Group, Ring, Field and Vector spaces, Subspaces, Basis, Galois field, Fermat's theorem and primitive elements. Linear independence and depcndence of vectors, Row and column spaces; Submatrices and partitioned matrices; Determinant, rank and inverse of a matrix; Determinant and inverse of partitioned matrices; Special matrices - Unitary, Similar, Hadamard, Circulant, Helmert's, Idempotent and Orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices, Permutation matrices, Full rank factorization. Generalized inverses, Moore-Penrose inverse, Applications of generalized inverse; Generalized inverse of partitioned matrices; Solutions of linear equations, Equations having many solutions; Spectral decomposition of matrices; Quadratic forms.

Optimization Techniques and Soft Computing: Classical optimization techniques. Constrained optimization. Optimization and inequality. Numerical methods of optimization. Direct Search method, Sequential Search method, Random Search method, Simplex Search method, Gradient method and Method of Steepest Ascent. Linear Programming Techniques - Simplex method, Duality and sensitivity analysis. Two-person zero-sum game and linear programming; Integer Programming. Statistical applications. Non-linear programming. Kuhn-Tucker conditions. Quadratic programming. Elements of Multiple objective programming. Dynamic programming. Optimal control theory. Soft computing tools - Artificial Neural Network, Support vector machines and probabilistic reasoning. Genetic algorithm, decision tree, Bayes classifiers, Fuzzy Logic. Rough Set. Simulation methods for various probability models. Resampling techniques: Jackknife and Bootstrap; Monte Carlo simulation.

11. Agricultural Structural and Process Engineering

Eligibility: Ph.D. in Agricultural Process and Food Engineering/Civil Engineering/ Processing and Food Engineering/Food Process Engineering/Food Processing Technology/Dairy Engineering/Post Harvest Process Technology/Post Harvest Engineering & Technology.

Syllabus:

Unit-1: Heat and Mass Transfer

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC, sorption and desorption isotherms, water activity and psychrometry. Modes of heat transfer, heat exchanger. Molccular diffusion in gases, liquids and solids, and biological solutions and suspensions. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Dimensional analysis and simulation, simulation models and mathematical modeling. Finite difference analysis, finite element analysis and their application in food process engineering.

Unit-2: Farm Structures and Farmstead Planning

Farmstead planning, survey and data collection for information bank, analysis of data, lay outs and cost estimation. Farm electrification, load estimation and selection of equipment, standby power Units, their selection, maintenance and operation, electrical fencing, safety devices including fire-fighting, households electrical wiring, illumination, transmission and distribution of electricity. Brooder house and incubation structures. Rat proof godowns, piggery, poultry and other livestock structures, feed stuff storage structures. Farm workshop, machinery and implement sheds. Fuel and chemical storage, biogas plant. Greenhouse construction, environment control, operation and maintenance, Design and layout ofpackhouses, food processing Units..

Unit-3: Storage Engineering

Storage environment and its interaction with stored products, factors influencing the shelf life of stored products, climatograph and deterioration index. Modeling of metabolic activities and prediction of storage life, quality deterioration mechanisms

and their control. Storage practices (including fumigation) for food grains (bag and bulk storage, godowns, bins and silos). Design of bulk storage and aeration system, analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, CA and MA systems and their design, smart storage system. Quality analysis of stored produce. Storage structures for animal feed, silage etc. Chilling rooms, walk-in cooling rooms for perishables. BIS standards on practices anddesign of systems for food grains/other commodities, CAP storage, hermatic storage etc.

Unit-4: Material Handling, Packaging and Transport

Bulk conveying equipment *viz.* belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors, operation and maintenance of conveying equipment, estimation of energy requirement, damage to products during mechanical handling. Packaging material characteristics and selection, packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Refrigerated containers and trucks for perishablefoods. Safety standards in handling, packaging and transport of agricultural produce. Types of packaging materials, barrier properties, CFB Boxes, modified atmosphere packaging, smart and active packaging, edible films, antioxidant and anti-microbial packaging, application of eco-friendly packaging materials, testing ofpackaging material. Micro and nano-encapsulation of food ingredients. Cold chain management. Damage and losses during transportation.

Unit-5: Post Harvest Operations

Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (osmotic, evaporative and freeze drying), pasteurization and sterilization of liquid foods, size reduction, cryogenic grinding, granulation, crystallization, filtration, membrane processing, microfiltration, ultra-filtration, nano-filtration, reverse osmosis, evaporation, distillation, mixing, clarification, coagulation, mechanical separation, sedimentation, pressing, expelling, leaching, extraction, palleting, extrusion and industrial fermentation.

Unit-6: Processing Technology and Equipment Design

Pre-milling/conditioning treatments. Theory of grain drying, thin layer and deep bed drying, novel dehydration techniques (osmotic, dehydration, foam-mat drying, puff drying, microwave drying, dehumidified drying). Process technology and machineries for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums. Bioprocess engineering, enzyme reaction kinetics, industrial fermentation and processing, down-stream processing, bio-separation. Minimal processing of fruits and vegetables, intermediate moisture foods, high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field. Food nano-technology. Seed processing and technology. Agricultural by-products/residue utilization, waste disposal of food processing plants, different methods and equipment. Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bioreactors, fermenters, centrifuges, cyclones, heat-exchanger, evaporators, filters, extrusion cookers. CAD and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selection of standard parts (pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses). Application of robotics and mechatronics in agro-processing operations.

Unit-7: Engineering Properties and Quality of Biomaterials

Uniqueness of bio-materials and physical characteristics *viz.*, size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose. Properties of bulk particulate solids *viz.* specific surface area, mean diameter, flow rate. Aerodynamics drag coefficient and terminal velocity. Pressure drop through packedbeds. Thermal properties such as specific heat, thermal conductivity, thermal diffusivity. Dielectric properties *viz.* dielectric and microwave radiation, dielectric constant, energy absorption, heating. Optical properties, transmittance and reflectance. Rheological properties, stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses. Food quality and BIS specifications for quality of food materials, milling quality analysis, cooking and baking qualities. Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, color, hardness, texture, nutritive value and microbial loads. Measurement techniques and instruments for

food quality determination, destructive and non-destructive quality evaluation, UV VIS NIR spectroscopy, X-ray, CT, NMR, machine vision. Maturity, ripening stages and indices of fruits and vegetables.

Unit-8: Agri-Project Planning and Management

Project development, market survey and time motion analysis. Selection of equipment, technology options, techno-economic feasibility. Processing in production catchments. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning. BIS/FSSAI/ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

Unit-9: Aquaculture Technology

Inland fish farming and associated considerations, site selection for aquaculture design of dykes, sluice, channels etc. Fish physiology and micro-climatic considerations, aeration and feeding systems, design of fish rearing structures, hatcheries, containers for live fish, fingerlings, fish seeds. Aquaculture in re-circulatory systems, oxygen and aeration, sterilization and disinfection. Re-circulation of water, re-use systems, water exchange, design of re-use systems. Inlet and outlet structures, water treatment plants.

Unit-10: Dairy Engineering, Instrumentation and Process Control

Principles of dairy cquipment design, design of vessels, design of milk storage tank, design considerations and design of heat exchangers, reaction vessels, high pressure vessels, evaporators, pasteurizers, cream separators, homogenizers, butter churn, drum dryer, spray dryer. Vapour compression refrigeration system, vapour absorption refrigeration system, heat pumps, design of refrigeration equipment, design of cold storage and air conditioning system. Advanced dairy processes, their operations and design, UHT processing, adsorption and sorption processes, electrodialysis, aeration and gas transfer. Dairy plant maintenance, food/dairy plant hygiene, HACCP in dairy/food processing industries. Static and dynamic characteristics of instruments, transducer elements, intermediate elements,

indicating and recording elements. Measurement of motion, force, torque, power, temperature, humidity, pressure and flow. Physical and chemical sensors, biosensors, fuzzy logic, neural networks and control. Monitoring of plant parameters through internet, data loggers, data acquisition systems (DAS). Introduction to direct digital control (DDC), supervisory control and data acquisition systems (SCADA), virtual instrumentation. Application of artificial intelligence in processing.

Unit-10: Statistical Methods

Probability and probability distributions. Principle of least squares. Linear and non-linear regression. Multiple regression. Correlation analysis. Selection of variables. Validation of models. Sampling techniques. Determination of sample size. Sampling distribution of mean and proportion. Design of experiments. Hypothesis testing. Concept of p-value. Student's t-test. Large sample tests. Confidence intervals. ANOVA and testing of hypothesis in regression analysis. Analysis of variance for one way and two way classification (with equal cell frequency). Transformation of data. Advantages and disadvantages of nonparametric statistical tests. Scales of measurements. Run-test. Sign test. Median test. Wilcoxon-Mann Whitney test. Chi-square test. Kruskal-Walli's one way and Friedman's two way ANOVA by ranks. Kendall's Coefficient of concordance.

12. Agroforestry

Eligibility- Ph.D. in Agro-forestry/Agronomy/Forestry/Environmental Sciences.

Syllabus:

Unit-1: General Forestry

Forests - Area and Extent - Reasons for decline in Forest Cover - Role of forests. Basis for classification and distribution in India - Geographical distribution of major world forest types. Forest types of India - Distribution and types. Forest ecosystems - Structure and functions. Forest Ecology - Forest succession and climax - Forest vegetation dynamics.

Unit-2: Silviculture

Silviculture - Site factors - Forest regeneration and ecology of regeneration - Silvicultural systems of high and coppice forest. Tree seed and nursery technology - Choice of species - Tending operations - Forest stand development. Silvicultural practices for short rotation forestry. Quantifying site quality and site index. Silviculture of important trees, *viz.*, Species, *viz., Populus deltoides, Eucalyptus tereticornis, E. camaldulensis, Dalbergia sissoo, Acacia catechu, Tectona grandis, Shorea robusta, Casuarina equisetifolia, C. junghuhniana, Pinus roxburghii, Gmelina arborea, Azadirachta indica, Albizia lebbeck, Diospyros melanoxylon, Pterocarpus santalinus, Santalum album, Quercus leucotrichophora, Dipterocarpus indicus, Melia dubia, Bambusa bambos, Dendrocalamus strictus, Salix alba, Cedrus deodara, Abies pindrow* and *Picea smithiana.* Plantation forestry - Energy and industrial plantations - Afforestation in wastelands and inhospitable sites - Precision silviculture - Mechanization of silvicultural practices - Certification of forests and plantations.

Unit-3: Forest Biology and Tree Improvement

Importance and applications of reproductive biology - Flower types - Pollination system - Sex expression - Floral biology and characteristics - Fertilization - Dispersal and gene flow. Forest genetic resource and diversity (FGR) - In situ and ex situ conservation of gene resources - On farm conservation - Handling and storage of FGR. Intellectual property rights - Quarantine laws and FGR exchange. Genetic constitution of trees - General concepts of forest genetics - Variation. Tree improvement - Concept of seed source/Provenance/Progeny/Clone - Breeding methods - Selection - Hybridization - Mutation - Migration. Genetic testing - GXE interactions. Seed Production Areas and Seed Orchards.

Mating designs - Clonal technology - Macro propagation in trees - Traditional cloning techniques - Protocols for micro propagation - Cryopreservation - Somaclonal variation - Anther and pollen cultures - Meristem culture - Embryo culture - Protoplast culture and cybrids - Forest biotechnology and its applications in forestry.

Unit-4: Agroforestry

Agroforestry - Classification - Agroforestry system and practices in different agro-ecological zones - Diagnosis and design of agroforestry system - Land capability classification and land use - Tree-crop-animal interaction - Biomass allocation patterns - Social forestry, CommUnity forestry, Urban forestry and Arboriculture. Sub-Mission on agroforestry - Green India mission and Bamboo mission. International and national organization in agroforestry research and development. Industrial agroforestry - Agroforestry value chain models - Contract tree farming system in India - Consortium approach - Tree insurance scheme in agroforestry. Multifunctional agroforestry system - Ecosystem services and environmental benefits. Financial analysis and economic evaluation Innovation in agroforestry - Agroforestry business incubation.

Unit-5: Forest Products and Utilization

Timber - Physical, mechanical, anatomical, chemical, electrical, acoustic and thermal properties of wood - Standard tests of timber - Mechanics and rheology of wood. Grading of timber (Teak, Rosewood, Sal, Redsanders and Sandal). Wood conversion - Wood working machineries used for primary and secondary conversion. Wood seasoning and preservation. Modified wood - Wood physics and Chemistry. Pulp and paper technology - Composite wood - Types - Wood adhesives and polymers - Biomass gasification and saccharification. Nanotechnology in wood and wood products - Value addition techniques - Briquettes - Biochar - Activated carbon. Non-Timber Forest Products - Classification, distribution, sustainable harvesting, processing, value addition and marketing of Gums, Resins, Katha and Cutch, Fibres and Flosses, Dyes, Tannin, Essentials oils, TBOS, Drugs, Bamboos, Canes and other NTFP Products - Role of tribal co-operative societies in NWFPs.

Unit-6: Forest Resource Management

Forest biometry - Measurements and volume of felled/standing trees - Volume tables - Biomass estimation - Increment. Predicting growth and yield - Yield tables - Stand growth and yield equations - Stand table projections. Forest management - Sustained yield and Normal forest - Rotation - Growing stock - Regulation of yield - Working plan - Joint Forest

management - Forest evaluation. Sustainable forest management. Deforestation and forest degradation - Invasive weeds in forests. Forest Soils - Nutrient cycles and dynamics - Management of problem soils - Soil and water conservation. Land use planning: Concepts and techniques - Watershed management & preparation of microplan. Ecology and Biodiversity - Hotspots. Ecosystem services - Inter-Governmental Science Policy Platform onBiodiversity and Ecosystem Services and Millennium Ecosystem Services Assessment. Quantification of ecosystem services - Eco certifications. Environmental Impact Assessments-Environment Management Plan - Participatory approaches. Remote sensing - Geo- referencing - Resolution - Digital Image Processing. Geographical information system - Global Positioning System. Drone & satellite application in forest resource monitoring.

Unit-7: Wildlife and Habitat Management

Wildlife Biology - Population dynamics - Habitat Management - Protected Area Network - Sanctuaries, National Parks, Tiger Reserves - Captive animal and Zoo Management - Central Zoo Authority - Human wildlife interactions.

Unit-8: Forest Policy, Legislation and Conventions

National Forest Policy 1894, 1952 and 1988 - Indian Forest Act, 1927 - Forest Conservation Act, 1980 - Wildlife Protection Act, 1972 - Biodiversity act, 2002 - Scheduled Tribes Act, 2006 - National Agroforestry Policy 2014 - Amendments in Forest and Wildlife Acts and Policies - International treaties (CITES, IUCN, RAMSER, CBD).

Unit-9: Climate Change and Mitigation Stratergies

Global climate change - Greenhouse gases - Carbon budget - Kyoto protocol, Marrakesh accord and Montreal agreement - UNFCCC, IPCC, CoP, LULUCF, REDD++ and CDM. Carbon foot prints - Restoration forestry. Agroforestry for climate change mitigation and adaptation. TOF sector in India.

Unit-10: Statistics

Definition, object and scope; Frequency distribution - Mean, median, mode and standard deviation - Introduction to correlation and regression - Hypothesis testing – Parametric and Non parametric tests - Experimental designs: Basic principles, Completely Randomized Design, Randomized Block Design, Latin Square Design and Split Plot Design.

13. Agronomy

Eligibility- Ph.D. in Agronomy/Soil Conservation & Water Management/Water Science and Technology/Natural Farming/Organic Farming/Sustainable Agriculture.

Syllabus:

Unit-1 : Current Trends in Agronomy

Agro-physiological basis of variation in yield, globalization of agriculture and WTO, precision farming, protected agriculture; contract farming; organic farming; conservation agriculture; soil-less cultivation; aeroponics, hydroponics, vertical farming and terrace farming; use of GIS, GPS, remote sensing and robotics for crop management in modern agriculture, use of block chain and big data analysis; contract farming; mechanization in crop cultivation systems; global warming and crop productivity; GM crops, GM seed production technology; seed certification, seed multiplication, hybrid seed production etc.; concepts of system agriculture; holistic approach of farming systems, artificial intelligence-concept and application.

Unit-2 : Recent Trends in Crop Growth and Productivity

Geo-ecological zones of India; crop growth analysis in relation to environment; capacity and intensity factors of plant growth; factors influencing vegetative (thermophase) and reproductive (photophase) of plants/crops; quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich's yield equation, its interpretation and applicability; Baule Unit; optimization of plant density and planting geometry in relation to different resources; concept of ideal plant type and crop modeling for desired crop yield; strategies for maximizing solar energy utilization; leaf area - interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; solar radiation concept and agro-techniques for harvesting solar radiation; growth analysis: CGR, RGR, NAR, LAI, LAD, LAR- concept, relevance, critical values; validity and limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems, root-shoot relationship; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition; heat Unit concept of crop maturity: concept and types of heat Units; concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.;

Unit-3 : Soil Fertility and Nutrient Management

Factors affecting soil fertility and productivity, problems of supply and availability of nutrients; relation between nutrient supply and crop growth; criteria of essentiality of nutrients; essential plant nutrients and their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients; commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; nano-fertilizer materials, methods of increasing fertilizer use efficiency; nutrientinteractions; time and methods of manures and fertilizers application; different approaches of fertilizers/ nutrients recommendations in crops and cropping systems, nutrient management sensors/ gadgets, foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; use of vermicompost and residue wastes in crops, integrated nutrient management;

Unit-4 : Water and Irrigation Management

Global water resources; water resources of India, irrigation projects during pre and post-independence period and their significance in crop production; field water cycle, water movement in soil and plants; soil-water-plant relationships; SPAC; soil and plant water potential; water absorption by plants; crop water stress – water deficits and crop growth; plant response to water stress; crop plant adaptation to moisture stress condition; irrigation needs; meteorological, soil, agronomic and plant factors affecting irrigation need; water deficits and crop growth; water movement in soil under saturated and unsaturated conditions; Poiseulle's and Darcy's law; general equation of saturated and unsaturated flow of water in soil; runoff and infiltration reciprocity; evaporation, transpiration and evapotranspiration, significance of transpiration; energy utilization in transpiration; water requirement of crop plants, water/irrigation needs, water use efficiency; management practices for improving water use efficiency of crops; factors affecting ET, control of ET by mulching and use of anti- transpirent; interaction between irrigation and fertilizers; fertilizer use in relation to irrigation; water availability in relation to nutrient availability; scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses; application of irrigation water, conveyance and distribution system, various irrigation efficiencies; agronomic considerations in the designand operation of irrigation projects; field water budget (water gain and loss at crop rootzone); characteristics of irrigation and farming systems affecting irrigation management; automated irrigation systems; strategies of using limited water supply; water harvesting, rain

water management and its utilization for crop production; hydroponics; water management of crops under climate change scenario; optimizing the use of given irrigation supplies; land suitability for irrigation, water quality; land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation; economic analysis of irrigation and cop planning for optimum use of irrigation water in command areas; use of models for water management.

Unit-5 : Recent Trends in Weed Management

Weed biology, ecology, and classification; crop-weed competition, interference and allelopathy; weed shift in different eco-systems - causes and effects; principles and methods of weed control; weed control indices, weed management in major crops and croppingsystems; alien, invasive and parasitic weeds and their management; migration, introduction and adaptation of weeds; invasive weeds – biology and management; different mechanisms of invasion – present status and factors influencing weed invasion; herbicides: introduction, history ; classification based on miscellany, chemistry, physiological/ biochemical actions, herbicide structure-activity relationship; factors affecting the efficiency of herbicides; herbicides absorption, translocation, metabolism and mode and mechanism of action; activity and selectivity and factors affecting them; herbicide formulations, herbicide mixtures and rotation, sequential herbicides application ; herbicides compatibility ; climatic factors and phytotoxicity of herbicides; Transformation/fate of herbicides in plant and soil and factors affecting them; residue management of herbicides; primary and secondary metabolites, adjuvants; trends in new herbicide products/molecules, application techniques and methods; herbicide resistance in weeds and management; antidotes and crop protection; compatibility of herbicides with other pesticides; development of transgenic herbicide tolerant crops; herbicide development and registration procedures; relationship of herbicides with tillage, fertilizer, irrigation and cropping system; bioherbicides and allelochemical, herbicide bioassays and chemical methods for residue analysis; recent advances in nonchemical weed management including deleterious rhizobacteria, biodegradable film, flaming, etc.; recent development in weed management; use of robotics, drones and aeroplanes, weed problems in organic production systems, organic herbicides; integrated weed management for inorganic and organic production systems.;

Unit-6 : Conservation Agriculture

Conservation agriculture (CA), principles, prospects and importance; advantages & disadvantages; conventional and conservation agriculture systems, sustainability concerns,

conservation agriculture concept, historical background , global experiences, present status in India; similarity/dissimilarity between resource conservation technology (RCT) and CA; similarity/dissimilarity between conservation tillage and CA; modern concept of tillage and its management conservation agriculture: nutrient management , water management , weed dynamics & management , energy use , resource- and input-use efficiency, insect pest and disease dynamics & management , farm machinery, crop residue management, cover crop management ; C-sequestration, soil health: physical, chemical and biological properties of soils; climate change adaptation and mitigation potential of CA and potential benefits; CA in agroforestry systems and rainfed/dryland regions; economic considerations and adoption of CA; constraints and future of agriculture under CA; policy issues.

Unit-7 : Cropping Systems and Sustainable Agriculture

Major cropping systems of irrigated, rainfed/dry land and semi-arid/arid environments and their approximate acreage in India; Resources capture and use efficiency, soil and water management in cropping systems; assessment of land use; concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria inassessing the yield advantages; competitive relationship and competition functions; biologicaland agronomic basis of yield advantage under intercropping; mechanism of yield advantage in intercropping systems; above and below ground interactions and allelopathic effects;competition relations; cropping patterns, alternate land use and crop diversification in rainfed and irrigated conditions; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture;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; advanced nutritional tools for big data analysis and interpretation; plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Unit-8 : Dryland Farming and Watershed Management

Concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture; soil properties and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, physiological principles of dry land crop production, constraints and remedial measures; characterization of environment for water

availability; crop planning for erratic and aberrant weather conditions; stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; management and breeding strategies to improve crop productivity under different patterns of drought situation under limited water supplies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions; tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; modernconcept of tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation, use of mulches, kinds, effectiveness and economics; anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use; concept of watershed resource management, problems, approach and components.

Unit-9 : Integrated Farming Systems and Sustainable Agriculture

Integrated farming systems, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation; farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply and enterprises; concept of sustainability of integrated farming systems; sustainability parameters and indicators; efficient integrated farming systems based on economic viability and natural resources – identification and management; production potential of different components of integrated farming systems; interaction and mechanism of differentproduction factors; stability of integrated farming system based on research/long term information in different systems through research; eco-physiological approaches to intercropping; integration of components and adaptability of different farming system based on land situations and climatic condition of a region; agro-forestry systems; evaluation of different IFS models; simulation models for intercropping; soil nutrient in intercropping; formation of different IFS Models; recycling of organic waste in IFS; new concepts and approaches of farming system and organic farming; alternate land use system; value addition,waste recycling, quantification and mitigation of green-house gasses; possible use of ITKs in integrated farming system.

Unit-10 : Soil Conservation and Watershed Management

Soil conservation; methods of soil conservation; soil erosion, nature and extent of erosion; types of erosion, factors affecting erosion; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts; watershed management: objectives, concepts, approach, components, steps in implementation of

watershed; development of cropping systems for watershed areas; drainage, methods of drainage, drainage considerations and agronomic management; land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Unit-11 : Principles and Practices of Organic Farming

Organic farming (OF) concepts, its relevance to India and global agriculture and future prospects; productivity and sustainability issues; principles of organic agriculture; selection and conversion of land, soil and water management - land use, role of conservation tillage ; shelter zones, hedges, pasture management, agro-forestry ; organic farming: water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, methods for enrichment of crop residues with minerals, micronutrients and its fortification; earthworms and vermicompost; green manures, bio-fertilizers and biogas technology; preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates, their composition, availability and crop responses; recycling of organic wastes and residue management; organic farming systems - selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity; weed, insect pest and disease management, biological agents and pheromones, bio-pesticides/ botanicals for pest management, indigenous practices and their importance in plant protection; marketing and export potential of organic products; quality standards, inspection, certification, labeling and accreditation procedures; organic farming and national economy; socio-economic impacts; organic farming ITKs, carbon and energy budgeting .

Unit-12 : Stress Crop Production

Stress and strain terminology; nature and stress injury and resistance; causes and mechanisms of stresses in plants; reactive oxygen species (ROS), scavenger enzymes, hormones/ growth regulators actions; mechanisms of drought tolerance; drought tolerance traits and their measurements; response of crop to acidity, salinity, sodicity, excess water and nutrient imbalances; low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through soil and crop manipulations; high temperature orheat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations; water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water

deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations; excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations; salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations; mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance; environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Unit-13 : Agronomy of Major Cereal/ Pulse/Oilseed/Fibre/Sugar Crops

Origin, history, area, production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of : *rabi* cereals and oilseeds (rapeseed, mustard, linseed and niger); *kharif* cereals and oilseeds (groundnut, sesame, castor, sunflower, soybeanand safflower) *rabi* pulses; *kharif* pulses; Kharif Cereals (Rice and Maize, Rabi Cereals (Wheat, Barley, Rye and Oats), Millets (Sorghum, Pearlmillet, Fingermillet and Minor Millets), Kharif pulses (Redgram, Greengram, Blackgram and Cowpea) Rabi Pulses (Bengalgram, Peas, Lentil, Lathyrus, Rajmash), Kharif Oilseeds (Groundnut, Sesamum, Castor, Sunflower, Soybean and Safflower), Rabi Oilseeds (Rapeseed, Mustard, Linseed and Niger) fibre crops (cotton, jute, ramie and mesta); sugar crops (sugarbeet and sugarcane); phenological studies at different growth stages of crop; estimation of crop yield on the basisof yield attributes; formulation of cropping schemes for various farm sizes and calculation of cropping; and rotational intensities; working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc); assessment of land use and yield advantage (rotational intensity, cropping intensity, diversity index, sustainable yield index crop equivalent yield, land equivalent ratio, aggressivity, relative crowding coefficient, competition ratio and ATERetc.); determination of cost of cultivation and harvest index of different crops.

Unit-14 : Agronomy of Fodder and Forage Crops

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne, etc.; adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage/grass crops; napier grass, *Panicum, Lasiuras, Cenchrus,* etc.; year-round fodder production and management, preservation and utilization of forage and pasture crops; 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; fodder production through hydroponics; azolla cultivation; economics of forage cultivation uses and seed production techniques of important fodder crops.

Unit-15 : Agronomy of Medicinal, Aromatic and Under Utilized Crops

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge; climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (citronella, palmarosa, mentha, basil, lemon grass, rose, patchouli, Geranium); (mulhati,isabgol, rauwolfia, poppy, *aloe vera*, atavar, *Stevia*, safed musli, kalmegh, Asaphoetida,*nuxvomica*, rosadle, etc); climate and soil requirements; cultural practices; yield of under- utilized crops (rice bean, lathyrus, sesbania, clusterbean, frenchbean, fenugreek, grain amaranth, coffee, tea and tobacco); post-harvest handling–drawing, processing, grading, packing and storage, value addition and quality standards in herbal products; quality characters in medicinal and aromatic plants; methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

Unit-16 : Agrostology and Agro-forestry

Agrostology: definition and importance; principles of grassland ecology; grassland ecology – commUnity, climax, dominant species, succession, biotype, ecological status of grasslands in India; grass cover of India; problems and management of grasslands; importance,classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses; Agroforestry: definition and importance; agro-forestry systems, agri-silviculture, silvi-pasture, agri-silvipasture, agri-horticulture, aqua-silviculture, alley cropping and energy plantation; crop production technology in agro-forestry and agrostology system; silvi-pastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agroforestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics. C and nutrients cycling and sequestration, and climate change adaptation and mitigation potentials of different agro-forestry systems.

Unit-17 : Agricultural Statistics

Frequency distribution, standard error and deviation, coefficient of variation, correlation and regression analyses, R^2, tests of significance- t test, F and chi-square tests, datatransformation and missing plot techniques, design of experiments and their basic principles, completely randomized, randomised block, split plot, strip-plot, factorial and simple confounding designs, efficiency of designs, methods of statistical analysis for cropping systems including intercropping; pooled analysis; contrast analysis, interpretation of tabular data.

14. Animal Biochemistry

Eligibility: Ph.D. in Veterinary Biochemistry/Animal Biochemistry/Veterinary Biotechnology/ Animal Biotechnology.

Syllabus:

Unit-1: Biophysical Chemistry and Membrane Biochemistry:

Physical and optical properties of biomolecules; Henderson-Hasselbach equation, pH, indicators and buffers; Colloids and their properties; Biomembranes- passive and active transport of ions and metabolites; Extra and intracellularcommunications; Role of membrane in cellular metabolism, cell recognition and cell to cell interaction; Signal transduction, ion and group translocation, ionophores, electrical gradient; Concepts of enthalpy, free energy and entropy; Energy coupling mechanisms.

Unit-2: Biochemistry of Biomolecules:

Structure of carbohydrates in cell surface, extracellular matrix, sugar code functions, peptidoglycan-specific antibiotics; Properties of lipids; Fat indices; Structure of plasma membrane; Membrane skeleton; Prostaglandins,steroids and fat soluble vitamins; Cardiac glycosides; Signaling biomolecules; Properties and structure of amino acids and proteins, extraction and purification, synthesis of peptides and proteins; Chemistry of purines,pyrimidines, nucleosides and nucleotides.Structure of DNA and RNA, properties of nucleic acids, base sequence analysis of DNA.

Unit-3: Enzymology:

Classes of enzymes, properties, kinetics and mechanisms of action, activation energy and transition state,coenzymes and cofactors, regulation and inhibition of enzyme activities; Enzymes and isoenzymes of clinical significance; Enzymes in Industry and in genetic engineering.

Unit-4: Analytical Techniques and Instrumentation in Biochemistry:

Instrumentation of Colorimetry, Spectrophotometry, Spectrofluorometer, Flamephotometer, AtomicAbsorption Spectrophotometer, ICP-AES. Principles of chromatographic, electrophoretic, ELISA, RIA, Immunoblotting, sedimentation, ultracentrifugation, Radiotracer and Tissue Culture Techniques; NMR spectrometry, X-ray crystallography, MassSpectrometry(LC/MS,GC/MS,MALDI-TOF,SELDI-TOF), Electronmicroscopy (SEM/ TEM/ STEM) ; Scanning Tunnelling Microscopy (STM).

Unit-5: Clinical Biochemistry of Animals:

Disturbances in water, electrolytes and acid-base balance-Role of lungs, kidneys and liver in pH homeostasis; Biochemical basis of diseases of carbohydrates, proteins, lipids, nucleic acids, minerals and vitamins metabolism; immune and endocrine systems; Synthesis, secretion, regulation, metabolic functions and physio-pathology of hormones;Lysosomes;Prostaglandins ; Liver, kidney, Thyroid, Pancreas, Rumen, Gastrointestinal and Heart function tests;Iso-enzymes-diagnostic importance; Oxidative stress; Biochemical markers of tumors; Disease Gene Mapping; Genetic diseases; Gene therapy.

Unit-6: Intermediary Metabolism and Regulation:

Glycolysis, pentose phosphate pathway, glycogenesis, bioenergetics, biological oxidation, respiratory chain and oxidative phosphorylation, citric acid cycle and ATP generation; Fatty acids and volatile fatty acids.Ketogenesis ; Biosynthesis of non-essential amino acids; synthesis of bioactive compounds from amino acids; Catabolism of amino acids, transamination and deamination;Urea cycle; Biosynthesis of sterols and phospholipids; Metabolism of purines and pyrimidines; Regulation of metabolic pathways; Endocrine regulation of milk biosynthesis.

Unit-7: Molecular Biochemistry:

Genetic information:Genetic code,DNA replication,repair mechanisms &gene expression in prokaryotes and eukaryotes; Transcription; Translation; Recombinant DNA technology; Recombinant proteins & vaccines; Cloning and expression vectors; Site directed mutagenesis, *In-vitro* transcription, Gene Silencing and transgenic animals. Gene Knock-out technology, miRNA, gene targeting and gene therapy;Design of biological systems;Nutrigenomics and Pharmacogenomics;Generation of antibody diversity; Monoclonal and Polyclonal antibodies; Hybridoma; Recombinant antibodies, Single chain and single domain antibodies ; Phage display library; Complement system.

Unit-8: Nutritional and Industrial Biochemistry:

Energy values of nutrients; absorption and biochemical changes; BMR,SDA, PER; Biochemical alterations due to phyto-toxins in ruminants; Feed additives; Agonists and antagonists of minerals and vitamins;Nutrient control of gene eXpression;Generation of gene-mediated products;fermentation technology for ethanol and biogasproduction; Conversion of sun light into biomass; Pharmaceutical products of animal and plant origin;Treatment of waste water, bioremediation of contaminated soils.

Unit-9: Introduction of Bioinformatics and Computational Biology:

Biological databases: Protein and Gene Information Resources; Computational biology; Sequence search algorithm and alignment tools: BLAST and FASTA;DNA and protein sequence analysis and databases; Tools of Multiple sequence alignment;cDNA libraries; Computer aided drug design:docking, QSAR, 2DQSAR, 3DQSAR and their concept;Multiple Genome sequencing, sequence assembly;Human genome, livestock and microbial genomes, Computational gene discovery; Gene and promoter prediction; Microarray technology;Protein structures- prediction and validation tools; RNA folding and secondary structure predictions; Metabolomics.

Unit-10: Environmental and Toxicological Biochemistry:

Environmental pollutants and toxicants;Effects on animal health and microbial metabolism; detoxification mechanisms ; Pollutant tolerance; Soil enzymes- source and role;Measurement of pollution; Pesticide residues.Environmental chemo-dynamics; Heavy metals and metalloids;Industrial chemicals and bio-toxins; Measuring water pollution, water treatment process; Biochemical oxygen demand and water quality assessment; methanogenesis and role of ruminants in global warming; Greenhouse gases, acid rain.Distribution,storage,target organ toxicity, biotransformation and elimination of toxicants and measurement of toxin levels;Hepatotoxicity and biochemical changes; Nephrotoxicity;Toxins and their effects on respiratory tract, endocrine and nervous systems, erythrocyte and haematopoietic system and oxidative metabolism.

15. Animal Biotechnology

Eligibility: Ph.D. in Veterinary Biotechnology/Animal Biotechnology/Veterinary Biochemistry/Animal Biochemistry/Animal Genetics & Breeding/Animal Breeding & Genetics.

Syllabus:

Unit-1: Cell Biology:

Structure and chemical composition of Carbohydrate, nucleic acids and protein. Properties of water. types of biological buffers. Prokaryotic and eukaryotic cell architecture, Molecularorganization and functions of cell membrane, cytoplasm, cell organelles, Nucleus, Nucleolus, nuclear transport etc. Active and passive transport of molecules and particles, exocytosis and endocytosis, Bioenergetic basics, The cAMP pathway, second messengers and protein phosphorylation. cGMP, phospholipids and Ca2+, Ras, Ra and the MAP kinase pathway, JAK/STAT pathway, Integrins and signal transduction. Cell division, cell cycle, Cell growth and differentiation. Control of cell proliferation and self-regulation. Cell motility. Cell trafficking and signalling. Apoptosis and molecular pathways. Protein secretion and targeting. Intracellular digestion. Oxidative Phosphorylation. Microscopy, cell counting, Karyotyping.

Unit-2: Molecular Biology:

Organization of chromosome. Different types of DNA sequences in mammalian genome. Structure of typical protein coding gene and their regulatory sequences. Overlapping genes. Mammalian non coding sequences. Transposons, retroposon, mini satellites and microsatellite sequences. DNA replication machineries Genetics of mitochondria. Transcription and translation in eukaryotes and their regulation. Transcription factors. Post-transcriptional and translational modifications. DNA-protein and protein-protein interactions. Transcription and translation in Bacteria and their regulation. Chromosomal and extra-chromosomal genetic materials. Plasmids and episome. Bacterial recombination .Genetic code, codon biasness.

Unit-3: Genetic Engineering and Recombinant DNA Technology:

DNA modifying enzymes: Restriction endonucleases, their types . Generation of DNA fragments by enzymatic and non- enzymatic means. Different types DNA and RNA polymerases (Mammalian, bacterial and viral). Molecular mechanisms of DNA repair. Different types of DNA end modifying enzymes for DNA labelling. DNA ligases. Reverse Transcriptase enzymes. Isolation and purification

of DNA and RNA from prokaryotes and eukaryotes. Plasmid DNA isolation methods. Quantification of DNA, RNA and proteins.Agarose and Acrylamide gel electrophoresis. Staining of DNA and protein in Agarose and Acrylamide gel. Cloning and expression vectors. Eukaryotic vectors-viral vectors and yeast expression system. DNA libraries (genomic and cDNA).Screening and characterization of DNA clones. Transformation of bacterial and animal cells. Different types of host expression system. Tagging / labelling of DNA and protein. Nucleic acid probes. GFP from jelly fish .Nucleic acid hybridization including *in situ* hybridization and FISH techniques. Autoradiography. Blotting techniques. Epitope tag. Nucleic acid sequencing methods including next generation sequencing. Chromatin Immuno precipitation assay. Genetically modified microbes. bioremediation, fermentation. Safety aspects and regulations associated with recombinant DNA technology. Patenting and Intellectual Property Rights.

Unit-4: Cell culture and Hybridoma Technology:

Nutrient requirements for cells of animal and fish origin. Media for culturing cells. Growth supplements. Primary cultures and established cell lines.Stationary, roller and suspension culture techniques. production of cells using bioreactors, microcarr iers and perfusion techniques. karyotyping, cryopreservation and revival. contaminants in cell cultures. Cell viability and cytotoxicity assays. Isolation and culture of lymphocytes. Micro-manipulation ofcells. Cell fusion, somatic cell hybrids, sub-cloning of cells.Principles and methods of hybridomatechnology. Production and characterization of monoclonal antibodies .Stem cells and theirapplications . Stem cells types. Induced pluripotent stem cells and their application in animal cloningand therapy.

Unit-5: Reproductive Biotechnology and Related Techniques:

Oestrus synchronization. Superovulation, Embryo collection and evaluation. Embryo splitting, sexing, transfer and their applications. Cryopreservation of gamete and embryos. Synthetic hormones for induced breeding in fishes. Androgenesis, gynogenesis, triploidy and polyploidy in fishes. Assisted Reproductive Technologies*: In vitro*/artificial fertilization. Ovum pick up, Embryo cloning, SCNT, Transgenictechnology. Production of transgenic animal/fish and gene farming. Intra cytoplasmic Sperm injection. Gene knock down knockout techniques.RNA interference (RNAi, siRNA, peptide nucleic acid). Gene silencing. Gene & genome editing tools. CRISPR / Cas types and their use in production of Genetically modified organism. Genetically modified animal/fish in human use.

Unit-6: Molecular Biology Techniques:

Protein purification methods. RFLP, RAPD and AFLP.DNA finger printing. Single Nucleotide Polymorphism .Polymerase Chain Reaction and Real-time PCR. Microarray techniques. Biosensors. Bioinformatics in biotechnology. Bioinformatics: Nucleic acid database (NCBI, DDBJ and EMBL). Protein databases . Specialised Genome databases . Structure databases Unique features of dairy animal specific protein Nucleic acid sequences.

Unit-7: Immunology and applied Biotechnology:

Immune system: Innate and adaptive immUnity, primary and secondary immune responses, ImmUnity against infectious diseases, autoimmUnity, immunodeficiency. MHC (Structure, functions and gene organization and its association with disease and resistance), Types and expression of Immunoglobulins .Chimerized and humanized monoclonal antibodies, recombinant antibodies. Antibody engineering. Single chain antibody, Camelid antibody, Phage and Ribosome display. Production of diagnostics, therapeutics and vaccines. Aptamers and theiruse in lieu of antibody. ImmUnity and vaccine against infectious agents