31. Fish Genetics and Breeding

Eligibility: Ph.D. in Fish Genetics & Breeding/Fish Biotechnology/ Fish Genetics/Aquaculture/ Fish Physiology & Biochemistry.

Syllabus:

Unit-1: Principles of Fish Genetics and Breeding

Mendelian inheritance, genetic variation; Multiple factor inheritance; Epistasis; Chromosomal theory of inheritance; Sex determination in fish; Gametogenesis; Linkage & crossing over, DNA as genetic material; Genetic code; DNA replication; DNA & plasmid isolation; Fine structure of chromosomes, chromosomal spread preparation technique & karyotyping, chromosomal aberration, chromosomal banding techniques, chromosomal manipulation; Ploidy induction; Gynogenesis; Androgenesis: Sex reversal.

Unit-2: Population Genetics

Genetics of population, gene & genotype frequencies & factors affecting them; Individual vs population, Qualitative vs. quantitative traits, Effective population size, estimation of inbreeding, F statistics, Wahlund effect, genetic similarity & Nei's genetic distance, Hardy-Weinberg principle; Systematic & dispersive forces changing gene & genotypic forces;Genetic bottleneck & mutation, genetic drift, Founder effect; Population genomics.

Unit-3: Quantitative Genetics

Basic concepts of General Linear Mixed Models; Population mean, variance, Estimation tools for population genetic parameters; Variance component estimation with complex pedigree, heritability, factors affecting heritability; Realized heritability; Correlation between traits, Breeding value: Biometrical relationship among relatives; Estimating fixed factors & predicting random effects-BLUE & BLUP; Models for EBV Selection: Aids & methods, Limits to selection, asymmetry of response to selection; Heterosis: Theories & estimation, Combining ability-GCA, SCA.

Unit-4: Selective Breeding of Aquaculture Species

National & International scenario of selective breeding programmes in aquaculture; Stock comparison methods; Genetic basis for selection of fish for breeding; Factors affecting rate of genetic improvement; Threshold characters; Heritability of threshold traits, genetic correlation

among threshold traits, selection for threshold traits, Managing inbreeding in hatchery populations, Formulation of breeding plans; Stock improvement plans for different population sizes & environments, Control population & experimental design Development of new strains/synthetic population; Inbreeding & Crossbreeding; Management of inbreeding; Selection & mating designs for growth, disease resistance, color enhancement; Genotype x Environment interaction; Application of markers QTL & MAS in selection program, production of SPF & SPR.

Unit-5: Fish Genetic Resources and Conservation

Fish genetic resources, Breeding strategies for threatened species; In situ & ex situ conservation: Issues & strategies; IPR issues of genetic resources; Regulations regarding introduction of exotic germplasm; Export import rules & regulations on conservation of aquatic genetic resources; Fish quarantine – status, procedures, scope & significance Convention on Biodiversity & National Biodiversity Authority of India; Access & benefit sharing of aquatic genetic resources of India; Effect of climatic change on biodiversity; Evolution & genetic diversity, maintenance of genetic diversity in natural & captive populations; Genetic variability & differentiation, equilibrium, null alleles, population genomics, outlier loci & adaptive variation in trait-related genes.

Unit-6: Molecular Genetics

Collection & storage of samples for DNA fingerprinting; Isolation & quantification of DNA from different sources; Concept of recombinant DNA techniques cloning & gene mapping; DNA markers in stock identification: Allozymes, RFLP, RAPD, AFLP, microsatellites, ESTs, SNPs, Type I & II markers, mtDNA & nuclear DNA markers, real-time PCR & EST markers, lab assays for markers; Next generation sequencing, applications for species identification, hybridization, stock identification, genetic diversity & conservation, parentage; Linkage & QTL mapping, microarray genes; Transgenics, GMO & biosafety regulations, transgenic containment; Use of biotechnological tools to improve aquaculture production; FISH (Florescence in-situ hybridization technique); Genotoxicity (MNT, sister chromosome exchange, comet assay).

Unit-7: Bioinformatics

Data mining tools & techniques, submission of DNA sequences, GenBank sequence database, genome diagnostics, genome & transcriptome analysis, protein information resource, EST database, phylogenetic analysis, microarray informatics.

Unit-8: Molecular Breeding

Mapping & identification of single genes in fish breeding; types of DNA sequences that create

single gene effect; Major genes, Polygenes & QTL identification & MAS; Molecular pedigree assigning; Genetic maps & candidate genes, Genome-wide association studies (GWAS) in pedigreed population, Methods & tools for GWAS; Introduction to genomic selection; Methodologies for genomic selection; Estimation of genomic breeding value, Factors affecting the accuracy of genomic selection; Genomic selection with low marker density; Genomic selection across populations & strains; Re-estimation of the chromosome segments; Designing breeding programs with genomic information.

Unit-9: Experimental Designs in Fish Genetics

Binomial, Poisson, Normal models; ANOVA, Multiple regression & correlation; Matrix operations; Determinants, inverse of matrix, linear equations, the matrix algebra of regression analysis; Linear Mixed Models (LMMs); Maximum likelihood (ML) & Restricted maximum likelihood estimation (REML) Estimation of Variance-Covariance Components; AMOVA; Model building & simulations; simulation of phenotypes; simulation of fish breeding in different conditions.

Unit-10: Fish Reproduction and Broodstock Management

Endocrine control of reproduction in fish & shellfish; Synchronization of spawning; Assessing the gamete quality; Controlled breeding; Genetic aspects of broodstock development & management; Methods of fish identification & pedigree maintenance; tagging methods; Packaging & transportation of fish seed & broodstock; Quarantine procedures; Aquaculture practices for genetically improved stocks; Nanotechnology & its application in fish breeding.

32. Fish Nutrition

Eligibility: PhD in Fish Nutrition & Feed Technology/Fish Nutrition/Fish Nutrition & Biochemistry/Fish Physiology & Biochemistry/Aquaculture

Syllabus:

Unit-1: Principles of Fish Nutrition

Sources and functions of proteins and amino acids, essential amino acids, non-essentialamino acids, ideal protein concept, amino acid antagonism. Scope of synthetic amino acid supplementation in plant based low protein feed. Sources and functions of lipids and fatty acids, role of essential fatty acids, phospholipid, cholesterol and steroids in fish nutrition. Sources and functions of carbohydrates in fish nutrition. Constraint in carbohydrate utilization, glucose intolerance in fish, strategies for improvement of carbohydrate utilization and protein retention. Vitamins and minerals, their classification and functions, vitamin- mineral interaction, mineral-mineral interaction, nutrient-mineral interaction. Protein to energy (P:E) ratio, protein sparing effect of lipid and carbohydrate, concept of low protein high energy eco-friendly feed.

Unit-2: Nutritional Biochemistry

Classification and structure of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals. Metabolism of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals, role of vitamin and minerals in nutrient metabolism, regulation of metabolic pathways. Structure and functions of enzymes, enzyme kinetics, activation and inhibition. Quality evaluation of protein and lipid, lipid peroxidation and antioxidants.

Unit-3: Nutritional Requirements and Feeding Management

Nutrients requirements at different life stages, factors affecting nutritional requirements in fish. Methods of studying nutritional requirement, response indices for nutrient requirement studies, dose-response curves, weight gain, specific growth rate, thermal growth coefficient, average daily growth, net protein utilization, physio-metabolic responses. Feeding methods and devices, ration size/feeding rate, feeding frequency and time, restricted and mixed feeding, record keeping. Nutrient cycles and food chain, nutrient loading through feed, high energy diets, low pollution diets, reducing pollution through additives. Impact of stress on feed intake and utilization, nutritional strategies to mitigate stress

Unit-4: Bioenergetics

Energy partitioning/flow, specific dynamic action (SDA)/heat increment of feeding, energy budgeting, energy requirement at different life stages, energy requirement/partitioning for maintenance, growth and reproduction.Energy estimation methods, factors affecting energy

requirements, energy estimation method in feed, concept of appetite and energy satiation, relationship among energetics of feeding, growth and reproduction, metabolic scope, intermediary energy metabolism, factors affecting energy metabolism.

Unit-5: Nutritional Physiology

Morphology, anatomy, histology and physiology of the digestive systems.Mechanism of feed intake and role of gustatory feeding stimulants, types of gustatory feeding behavior, biotic and abiotic factors affecting feed intake, techniques for measurement of voluntary feedintake, neuroendocrine regulation of feed intake, circadian rhythms of feeding activity .Gastro-intestinal motility, digestion, absorption, transportation and assimilation of nutrients in finfish and shellfish, digestive enzymes in finfish and shellfish, neural and hormonal regulation of digestion, hormonal control of nutrient metabolism, dry matter and nutrient digestibility of feed and ingredients, factors affecting digestibility, microbial digestion in finfish and shellfish. Short term effects of meal on post-prandial levels of nutrients, physiology of starvation and feed restriction. Osmotic and ionic regulation; acid base regulation, mechanism of gill ventilation, gaseous exchange and respiratory mechanisms, mechanism of excretion of nitrogenous waste, mechanisms of osmoregulation, excretory and osmoregulatory organs; nutrients and osmoregulation.

Unit-6: Reproductive Physiology

Formation of eggs and spermatozoa; neuroendocrine regulation, vitellogenin: structure, synthesis and transportation to oocytes; egg envelop proteins; gonadal steroidogenesis; physiology of fertilization; mechanism of egg activation, metabolic changes during gametogenesis; nutrient regulation of gonad development & endocrine function; seminal vesicle and function. Cryopreservation of milts/germ cells, process of sex reversal, development of surrogate brooders. synthetic hormones and analogues for induced spawning, artificial insemination, stripping and in-vitro fertilization.

Unit-7: Broodstock and Larval Nutrition

Role of nutrition in gonadal development, maturation and reproductive performance (fecundity, fertilization, embryonic development, larval survivability etc.), special ingredients for broodstock feed, special feed for conditioning, maturation and reproduction, bioenergetics of spawning, energy relationship between egg and hatchlings, energy flow during early ontogenesis, nutritional profile of egg yolk, utilization of egg protein, amino acids and lipid, abiotic factors influencing yolk absorption, criteria for evaluation of early larval development. Ontogenesis of digestive system, digestion and absorption of nutrients (protein and lipid), mechanism of transition from endogenous to exogenous feeding and nutrition,

importance of live food and formulated micro-particulate feed in larval nutrition, nutritive value of live food, live food enrichment, weaning and co-feeding strategies for better growth and survival, bottlenecks in larval nutrition, nutritional programming.

Unit-8: Feed Formulation and Feed Technology

Principles and prerequisites of feed formulation, different methods of feed formulation and their limitations, use of feed formulation software.Feed ingredients, scope and exploration of new unconventional feed ingredients, physical and nutritional quality evaluation of feed ingredients, anti-nutritional factors and methods of detoxification, feed additives, binders and nutraceuticals, storage of ingredients and quality assurance .Manufacturing process of different types of farm made and commercial feed, Manufacturing of microparticulate larval feed, medicated feed and designer feed, factors affecting feed manufacture, effect of processing on nutrition value of feed, feed processing quality assurance, processed feed quality assurance, miscellaneous adventitious toxins and effect on feed safety, storage of processed feed and quality control, prevention of storage loss, BIS and international standard for aquafeed formulation and manufacturing .Layout, design and safety operation of feed mill, feed mill maintenance and record keeping, economics of feed manufacturing.

Unit-9: Nutritional Pathology

Nutrients and their effects on fish health, nutrient deficiency and toxicity diseases, Antinutritional factors, toxic principles, mycotoxins and their effects on fish health. Nutraceuticals and their role in fish health; nanodelivery systems, nutraceuticals and stress mitigation, Diet and flesh quality.

Unit-10: Nutrigenomics

Concept of nutrigenomics, regulation of gene expression, nutritionally important genes, nutrient-gene interactions, Omic studies, transcriptomics, proteomics, metabolomics and techniques used in omics studies, softwares used in gene expression studies.

33. Fish Processing Technology

Eligibility: PhD in Fish Processing Technology/Post Harvest Technology/ Fish Quality Assurance and Management.

Syllabus:

Unit-1: Fish Biochemistry

Proximate composition – Proteins- classification- Fish muscle proteins- Structure -Myosin – Actin- other structural protcins – Stroma proteins - classification- functional properties- solubility – gel forming ability – water holding capacity – emulsifying capacity – protein denaturation. Lipids-types –Membrane lipids – Cholesterol – Essential fatty acids – EPA & DHA – Arachidonic acids - structures- lipid oxidation- Pro- and anti- oxidants- Lipid-protein interaction- Lipidomics – Eicosanoids and their functions. carbohydrates- classification- structure and properties - vitamins and minerals- health benefits- seafood flavors and pigments – Myoglobin – Hemoglobin- Myocyanin - allergens – Antifreeze proteins. NPN compounds- Fresh Fish quality- Post mortem changes.

Unit-2: Microbiology of Fish and Fishery Products

Microbial activities in different foods in relation to intrinsic and extrinsic parameters. Control of microorganisms in foods. Microbes as processing and preservation aids. Microbialactivity and spoilage in fish & fishery products -Modification of intrinsic and extrinsic parameters for fish preservation -Food borne pathogens of public health significance- infection and intoxication- virulence- incidences – prevention- Sources of contamination and control measures -Isolation and identification of pathogens- Microbial spoilage of fresh, semi processed and processed fish and fishery products; Microbial quality standards for export trade.

Unit-3: Low Temperature Preservation of Fish

Chilling of fish : Principles- Types of chilling- Icing -quality of ice- ice making- onboard handling of fish-chilling rate; spoilage of fish during chilled storage - Fish freezing: principles- freezing point depression, eutectic point; Glass transition- freezing rate- crystallization and recrystallization- Freezing rate calculation -Types of freezers- Methods of freezing – Quality changes during frozen storage- microbiological, physical and chemical changes- Prevention of quality loss- Cryoprotectants-Glazing -Drip loss. Thawing: Principle -Methods of thawing - Sanitation in freezing plants - HACCP in freezing industry- National and International Quality standards-. Accelerated freeze drying. Requirements for construction of cold storage; Types of cold storage. Cold chain system.

Unit-4: Fishery Products

Principle of fish preservation and processing. Intrinsic and extrinsic factors-Handling of fresh fish-Hurdle technology in fish preservation. Preservation of fish by curing: salting, sundrying, smoking, marination and pickling; and fermentation -Fish paste products. Drying and dehydration- principles - water activity – drying kinetics-hysteresis in fish drying process-Artificial drying- solar dryers- Mechanical dryers - Irradiation preservation – Novel processing techniques-High pressure processing, Pulsed electric field, Dielectric heating, ohmic heating Quality standards.

Unit-5: Thermal Processing of Fish

Classification of food based on pH —Principles of thermal processing- mechanism of heat transfer- heat penetration studies -cold point – sterility- heat resistance of bacteria and spores-TDT, D vale, Z value and Fo value- 12 D concept -Cook value- Types of packaging matcrials for canned foods- Types of containers – metal containers (Tin Plate, TFS, Aluminum cans)-Manufacturing of cans -Canning Unit operations - HTST and UHT processing – Aseptic canning- Retort pouches-properties, manufacturing, retort pouch processing- -over pressure retort-Methods of thermal process calculation- Spoilage of canned foods - Quality standards-Thermobacteriology- *Clostridium botulinum* – Neurolytic toxin.

Unit-6: Valuc Addcd Fishcry Products

Concepts of value addition - Fortification of food- types of value addition - Machineries requirement- Mince based products - Surimi preparation- Mechanism-Machineries Requirement-Packaging- Storage- Quality evaluation -Analogue products - Battered and breaded products - Freeze dried products - Ready to eat and ready to cook products - extruded products- Mechanism of extrusion- Type of extruders – Fortification of foods-Seaweed based products.

Unit-7: Fish By- Products and Waste Utilization

Fish meal, FPH, fish silage, fish oils-squalene- shark cartilage- ambergris- extraction of collagen, gelatin and enzymes- carotenoids-chitin-chitosan- glucosamine- carotenoids – FPH - bioactive peptides- Industrial waste – liquid and solid waste in fish processing- Anaerobic treatment- Animal feed production- Biodiesel production – biogas production- Industrial application

Unit-8: Biochemical Techniques for Food Analysis

Instrumental analysis of micro and macro molecules (chromatographic, electrophoretic, spectroscopic techniques)-Measurement of functional and rheological properties. Bioactive compounds, Biotoxins and contaminants: Bioaccumulation and Biomagnification- - Heavy

metals – Pesticides- Antibiotic residues- Toxicity- Tolerance limits- Detection methods. Bioactive peptides – ACE inhibitory peptides – nutritional significance.

Unit-9: Food Additives in Fish Processing

Classification of food additives-preservatives-antioxidants- emulsifiers – Stabilizers – Food colors – Flavours – sequestrants - anticaking agents- humectants – firming and crisping agents – Sweeteners - enzymes – Hydrocolloids – functions and significance as food additives - Nutritive additives - Cryoprotectants, etc. - Risks and benefits of food additives – Health considerations and safety evaluations – Laws related to additives - GRAS additives – Adulteration and preventions.

Unit-10: Packaging of Fish and Fishery Products

Principles and purposes – Packaging materials- Basic films and laminates - Properties and testing methods of packaging materials - Packaging for live fish transportation – Chilled and frozen fish-Vacuum packaging - Modified atmospheric packages- Package designs - Labeling and printing - Edible packaging- Biodegradable packaging, Active packaging, Intelligent/Smart Packaging and RIDF Technology-Disposal and recycling of packaging materials - FSSAI and BIS guidelines

Unit-11: Techniques in Seafood Quality Assessment

Molecular methods – PCR - Rt-PCR - AFLP- RFLP- Hybridization- DNA barcoding- Microarray- Principles and applications – Immunological techniques- Antigen – Antibody reactions- Immunoassays - ELISA, IFAT- Principles and applications -seafood fraud/adultrants- Authenticity testing. Microscopic techniques-Direct epifluorescence methods

Unit-12: Fish Quality Assurance and Management

Factors affecting seafood quality- Quality assessment: Sensory, Instrumental and Biochemical- Hazards: Physical, chemical and biological hazards- Quality Assurance, Quality Management, Total Quality Management – GMP – SSOP- HACCP for seafood industries: Principles and Applications -Risk analysis and assessment-Plant sanitation - Plant layout (canning plant, fish meal plant, surimi plant, freezing plant) - Personnel hygiene – water quality- Pest control – Environment, energy and food safety standards.

UNIT-13: Seafood trade regulation and certification

Seafood Trade - World Trade Organization - Sanitary and Phytosanitary (SPS) Agreement - Technical Barriers to Trades (TBT) Agreement- Food laws and standards - Legislation for export - Role of EIA and MPEDA in seafood export- IPQC, Self-Certification, food safety management systems based certification- Processing Plant Registration -Fishing Vessel Registration -Processing Plant Approval -Monitoring Schedule -Health Certificate -Internal Alert- Recall procedures -Catch Certificate- Pre-Harvest Test Certification -Seafood regulation- EU, USFDA, FSSAI , ISO, Codex Standards - Seafood audit : GFSI, BRC – Ecolabelling-Traceability.

34. Fisheries Resource Management

Eligibility: Ph.D. in Fisheries Resource Management/Aquatic Environment Management/Fishing Technology & Fishery Engineering/Marine Biology/Aquatic Biology/Aquaculture.

Syllabus:

Unit-1: Fisheries Resources

Major fisheries resources of the world and India, trends in production; Commercially exploited fish and shellfish stocks of India - their distribution, potentials, status, means of exploitation and yields; Target and non-target fisheries resources of the Indian subcontinent and the Exclusive Economic Zone (EEZ); Distribution, composition, trends and dynamics of major exploited fishery resources in hill streams, rivers, reservoirs, lakes, lagoons, estuaries, territorial waters, oceanic waters, deep sea and oceanic islands; Ancillary aquatic living resources - sponges, corals, mammals, reptiles, echinoderms, amphibians, seaweeds, seagrass, sea snakes, mangroves; Resources associated with open sea and sea mount; Straddling/shared stocks and non-conventional resources; Sports, game and ornamental fisheries; Underexploited and unexploited fish stocks of India.

Unit-2: Fish Biology and Functional Physiology

Biosystematics of commercially important fish, shellfish, aquatic mammals, reptiles and amphibians; Modern tools in ichthyotaxonomy; Zoo-bank; Fish phylogeny and zoo-geography; Speciation; Feeding, reproductive and developmental biology of commercially important finfish and shellfish; niche overlap; fish assemblages; ontogenic changes in food and feeding, bioenergetics, use of biomarkers; Age and growth studies; Application of tagging and marking in fisheries, satellite tags; Fish migration, use of acoustics, e-DNA and automation fish migration monitoring; Structures and design of fish passes; Fish radiography;Physiological mechanisms of osmoregulation, reproduction, buoyancy, swimming and endocrine system in fish and shellfishes; Fish cognition and behavior; Ecophysiology; Stress physiology.

Unit-3: Fish Stock Assessment

Concept of fish stock; Characterization and delineation of fish stock – truss network, use of otoliths population parameters, molecular markers; Sampling and data collection methods; Methods of estimating stock abundance; Indicators and reference points; Recruitment, growth and mortality of fish in natural water bodies; Gear selectivity; Dynamics of fish stock-

recruitment relationships; Fish stock assessment models - holistic models, analytical models, multispecies models, stochastic models and bioeconomic models, rapid stock assessment, their advantages and disadvantages; Cohort dynamics; Fish stock regeneration time, resilient stock; Catch reconstruction; Catch per Unit effort; Concept of Maximum Sustainable Yield and Maximum Economic Yield; Prey-predatory models, Productivity models, ECOPATH with ECOSIM; Computer softwares in stock assessment.

Unit-4: Fishing Technology

Different types of fishing crafts and gears, operation and their maintenance; Boat building materials, fishing gear materials, advantages and disadvantages; Evolution of mechanization of crafts in India; Safety measures for the fishing boats; Selectivity of trawls, gill nets and lines; Recent advancements in the construction of active fishing gears; Fishing gears and crafts for deep sea fishing; Green fishing practices; By-catch reduction devices, turtle excluder devices, finfish and shrimp excluder devices; Use of modern techniques and electronic equipment for fish finding, aggregating and capturing; Gear impact on fishery resource. Vessel monitoring system.

Unit-5: Sustainability Issues in Fisheries

Promoting fisheries with sustainable development goals in terms of livelihood, nutrition, income and employment; Components and indicators of sustainability; Issues in fisheries - overexploitation, overcapacity, ghost fishing habitat degradation, bycatch and discards, destructive and prohibited fishing systems and practices, minimum legal size; damming of rivers, interlinking of rivers, environmental flows, climate change; Fishing conflicts - exotic species and their impact, accidental introductions, invasive species, transboundary issues, Illegal, Unreported and Unregulated (IUU) fishing; Land and water body issues; Gender equity; Traceability certification.

Unit-6: Fisheries Management and Responsible Fisheries

Concepts and principles of fisheries management; Fisheries biosystems; Indicators and reference points of sustainability, fishing balance index, marine trophic index; Anthropogenic intervention, stock enhancement and sustainable management approaches in riverine, reservoir, lacustrine, floodplain wetlands and marine fisheries; Modes of fisheries management – open access, regulated, advisory, participatory, user rights; Input controlmeasures - access control and limited entry (size, type, number and power of boats, duration of fishing), licensing, capital investment; Output control measures - total allowable catch, catch quotas; Technical control measures - size limitations, closed areas, closed seasons, eumetric fishing and mesh size regulations; Large Marine Ecosystem (LME) approach; Responsible fisheries, co-

management, right based fishing, Management of conflicts within sub-sectors in fisheries; alternative livelihood options; Ecosystem based fishery management; Use of block chain technology and artificial intelligence in fisheries management; MSC certification.

Unit-7: Geospatial Information Services in Fisheries

Principle and methods of geospatial information; Remote sensing and Geographic Information System (GIS) in fisheries, resource mapping, modeling and forecasting; Mechanisms, methods and status of fish yield data acquisition; Potential fishing zones;Application of GIS in the management of mangrove forests and marine protected areas; Monitoring, control and surveillance (MCS) systems for major fisheries.

Unit-8: Aquatic Ecosystem and Restoration

Aquatic habitats – freshwater, estuaries, and marine – their structure, functions, ecological services, productivity and carrying capacity; Trophodynamics and energy flow in aquatic ecosystems, ecological nice, trophic indices and modeling; Plankton and benthos, their role in productivity; Chemical interactions, nutrient dynamics and cycling, bioindicators, bioaccumulation, bioconentration and biomagnification; Ecological stability and homeostasis; Aquatic pollution and impacts on aquatic resources; Habitat degradation and its impact on fisheries; Synoptic oceanographic analysis – currents, waves, tides, El Nino- southern oscillation; Stratification, mudbanks, upwelling, downwelling and circulation patterns ocean circulation and fisheries; Fisheries forecasting using environmental parameters; Application of bioprocesses – bioremediation, biomanipulation, bioaugmentaion, biofouling; Ecorestoration – planning, recovery process, challenges, participatory approach; Methods for increasing productivity of water bodies (use of thermal energy and deep-sea water through artificial upwelling, ranching). Ecoinformatics; Water budget, river continuum concept; Influence of environmental parameters on fish abundance, distribution, fish production and resource resilience; harmful effects of algal blooms on fisheries; Ecosystem valuations, Environmental Impact Assessment (EIA); Integrated coastal zone management (ICZM); Vulnerability of fishers to natural disasters and coping mechanisms Integrated Environmental Management (IEM), Waste water treatment and recycling; Valuation of aquatic ecosystems.

Unit-9: Aquatic Biodiversity and Conservation

Biodiversity – species, genetic and ecosystem; Biodiversity assessment and indices, Index of Biological Integrity (IBI), economic appraisal of biodiversity; Endemic biodiversity; Biomonitoring, bioprospecting and biopiracy, Influence of environmental parameters on fish abundance, distribution, resource resilience; Species concept for conservation related decisions - unique species, umbrella species, flagship species, keystone species, state fish

concept; Threats to fish diversity; Genetic impacts of threats; biodiversity conservation methods - ex situ and in situ; IUCN criteria, IUCN-Red List; Participatory approach; Conservation value index; IUCN-Green List. Rebuilding and restoration of fish stock; Conservation biology - Concept of hotspots, Endangered, Threatened and Protected (ETP) species, ecological integrity, minimum population sizes, Allele effect, genetic tolerance of extreme conditions, extinction risk assessment.

Unit-10: Management of Ecologically Sensitive Areas

Ecologically sensitive areas (mangrove, corals, seagrass beds, mudflats and dunes, turtle nesting grounds, horseshoe crab habitat, protected areas, biosphere reserves, salt marshes; freshwater wetlands), their distribution, ecological role, associated fauna and flora – taxonomy, adaptations and biology; Issues, management, regulations and conservation strategies.

Unit-11: Climate Change and Fisheries

Climate change, causes and its impacts on sensitive aquatic ecosystems, capture fisheries and fish abundance, distribution and physiology; Carbon footprint in fisheries and its impacts on fisheries (temperature rise, ocean acidification, coral bleaching, Ocean acidification; Global ocean circulation; El Nino and Southern Oscillation, IPCC and its reports, UNFCCC, Kyoto Protocol; Global and regional models on climate change and fisheries; Mitigation and adaptation strategies - resilience, vulnerability and risk assessment, institutional mechanisms.

Unit-12: Fisheries Legislations and Regulations

Fisheries policies, instruments and mechanisms for fisheries management; Overview of fisheries acts and legislations, revisions and amendments; National policies and regulations – Indian Fisheries Act, The Environmental (Protection) Act; Wildlife protection act, Maritime Zones of India Act, Biodiversity Act, National policy on fisheries, Territorial sea, Contiguous zone, Exclusive Economic and Fishery Zones Act; MFRA, Deep sea fishing policy, Guidelines for deep sea vessels, Coastal Regulation Zone notification, green certification, fish catch certificate, MPEDA Act; International fishery regulations, treaties and instruments – UNCLOS, UNFSA, FAO-CCRF, CITES, CMS, Ramsar Convention, MARPOL, BASEL, CBD, IWC, IOTC, RFMOs, BOBP, EU's common fisheries policy, Ecolabelling and certification in fisheries; Impact of fisheries regulations on the fisher communities.

35. Floriculture and Landscaping

Eligibility: Ph.D. in Floriculture and Landscaping/Floriculture and Landscape Architecture/Horticulture/Post Harvest Management/Post Harvest Technology.

Syllabus:

Unit-1: Production Technology for Loose Flowers

Scope and scenario: Scope scenario and importance of loose flowers nursery management, pro-tray nursery under shade nets, transplanting techniques; Soil analysis field preparation, systems of planting, Water and nutrient management, weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM; Crop regulation: Flower forcing and year round flowering, chemical regulation Post harvest management and marketing: Harvest indices, harvesting techniques, post- harvest handling and grading, packing and storage, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones: Crops- Jasmine, scented rose, chrysanthemum, marigold, China Aster, tuberose, crossandra, nerium, spider lily, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, water lilies, tecoma, champaka, balsam).

Unit-2: Production Technology of Cut Flowers

Scope and scenario: National and International scenario, Importance and scope of cut flower trade, constraints for cut flower production in India. Growing environment, soil health and analysis, open cultivation, protected cultivation, Soil/media planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering; Crop management – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, Flower regulation: Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation; Post harvest management and marketing: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, crop insurance Agra Export Zones; Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthodium, aster, lilies, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophila,solidago, limonium, statice, stock, cut greens and fillers.

Unit-3: Protected Floriculture

Principles and types: Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc. Principles and design: Principles and designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation; Environment control – Microclimate management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturallyventilated greenhouses, fan and pad cooled greenhouses, light regulation; Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM; Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation; Automation and standards : Sensors, solar greenhouses, GAP/flowerlabels, Export standards, EXIM policy, APEDA regulations for exports.

Unit-4: Value Addition in Floriculure

Scope and scenario: Scope and prospects of value addition, National and global scenario, productionand exports, Women empowerment through value added products making, supply chain management; Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, Morebana, freestyle, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations; Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, potpourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Extraction of valuc addcd products: essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Aromatherapy Pigments and nutraceuticals: Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments as nutraceuticals, Extraction methods; Applications in food, pharmaceuticals and poultry industries.

Unit-5: Nursery Management, Seed Production of OrnamentalPlants and Specialty Flowers

Scenario of nursery industry, sexual and asexual propagation micro propagation and nursery management, sanitary and phytosanitary issues, nursery standards, etc. Seed production in

flower crops: Scenario of seed industry, scope and importance of seed production in flower crops seed production methods and improvements, seed regulations, Specialty flowers, fillers and cut greens: Importance, National and International scenario, Specialty flowers and cut greens cultivation, trade and marketing.

Unit-6 : Breeding of Ornamental Plants

Principles - Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India; Genetic inheritance - of flower colour, doubleness, flowersize, fragrance, post-harvest life; Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops; Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium; Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy). Role of biotechnology in improvement of flower crops – Somaclonal variation, invitro mutagenesis, genetic engineering molecular markers etc. Somaclonal Variation, transformation, invitro cryopreservation, somatic hybridization, Anther and ovule culture, somatic embryogenesis, biosynthetic pathways, pigments, fragrance, senescence, chemistry and importance of secondary metabolites, genomics, proteomics, metabolomics,molecular breeding, marker assisted selection, genome editing, CRSIPER/CAS etc.

Unit-7: Ornamental Horticulture & Landscaping

Historical background of gardening, Importance and scope of ornamental gardening, Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, *Vanams or* Hindu type of gardon, Buddha garden; Garden components (living and non-living), arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Specialized gardens: vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, Zen garden; Principles and elements of landscaping : Basic drawing skills, garden symbols, steps in preparation of garden design Elements and principles of landscape design: visual aspects of plan, Landscaping for different situations: Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals,

roadsides, traffic islands, damsites, IT/SEZ parks, corporates; Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components.

Unit-8: Turf Grass Management

Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment; Types of Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens; Preparatory operations; Growing media used for turf grasses - Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, synthetic turfing; Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing,use of turf growth regulators (TGRs) and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs; Turf for different grounds : Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, residential and public parks, turfing for govt. and corporate office gardens, turf colourants.

Unit-9: Computer Aided Designing (CAD) for Landscaping

CAD basics and applications : Principles of integrating the architecture and landscaping Exposure toCAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing; 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects; Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout; 3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD; ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using Photoshop, Making sample drawing for outdoor and indoor gardens.

36. Food Technology

Eligibility: Ph.D. in Food Technology/Food Science and Technology/Agricultural Processing and Food Engineering/Processing and Food Engineering/Food Process Engineering/Food Processing Technology/Dairy Engineering/Dairy Technology/Post-Harvest Process Technology/Post-Harvest Engineering & Technology/Livestock Products Technology/Food Science and Nutrition/Food and Nutrition.

Syllabus:

Unit-1: Introductory Food Technology

Introduction to food technology. Food processing industries/institutions/food scientists of importance. Food attributes viz. colour, texture, flavour, nutritive value and consumer preferences. Causes of food spoilage, sources of microbial contamination of food, food borne illnesses, water activity and its relation to spoilage of foods. Spoilage of processed products and their detection. Principles and methods of food preservation. Food fortification, composition and related quality factors for processing. Methods of food preservation such as heat processing, pasteurization, canning, dehydration, freezing, freeze drying, fermentation, microwave, irradiation and chemical additives. Refrigerated and modified atmospheric storage. Aseptic preservation, hurdle technology, hydrostatic pressure technology and microwave processing. Use of non-thermal technologies (ohmic heating, dielectric heating, infrared and induction heating) and biological technologies (anti bacterial enzymes, bacteriocins, proteins and peptides) in food processing.

Unit-2: Introductory Food Engineering

Units and dimensions, system and state of a system, density, concentration, moisture content, temperature, pressure, enthalpy, equation of state and perfect gas law, phase diagram ofwater, conversion of mass for open and closed system, material balances, thermodynamics and laws of thermodynamics, energy and energy balance for closed and open system, Size reduction: grinding and cutting, new surface formed, energy used in size reduction, size reduction equipment, emulsification and preparation of emulsions. Mixing: characteristics of mixtures, measurement of mixing, energy input in mixing, mixing equipment. Mechanical separations: the velocity of particles moving in a fluid, sedimentation, flotation, settling undercombined forces, centrifugal separations, filtration, constant-rate filtration, constant-pressure filtration, filter-cake compressibility, filtration equipment, sieving and sieving equipment.

Unit-3: Fluid Flow in Food Processing

Liquid transport systems, properties of liquids, handling systems for Newtonian liquids, force balance on fluid element flowing in a pipe, energy equation for steady flow of fluids, pump selection and performance evaluation, flow measurement, measurement of viscosity, flow characteristics of non-Newtonian fluids, energy losses in flow, measurement of pressure in a fluid, measurement of velocity in a fluid, pumps and pump characteristics, fans and fan laws. Transport of solid foods, process controls in food processing and sensors.

Unit-4: Engineering Properties and Quality of Biomaterial

Sampling, Uniqueness of bio-materials and physical characteristics *viz.* size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose. Food powder bulk properties viz. flowability, caking behaviour, rehydration, reconstitution, sinkability, dispersibility, solubility. Food powder particle properties: particle shape, density, morphology, size distribution, surface area and moisture. Adhesion of food powder. Aerodynamics drag coefficient and terminal velocity. Pressure drop through packed beds. Thermal properties such as specific heat, thermal conductivity, thermal diffusivity. Dielectric properties *viz.* dielectric and microwave radiation, dielectric constant, energy absorption, heating. Optical properties and transmittance and reflectance. Rheological properties and 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, bio-availability and microbial loads, non-destructive quality evaluation techniques. 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-5: Heat and Mass Transfer in Food Processing

Systems for heating and cooling food products, thermal properties of foods, modes of heat transfer, steady-state and unsteady-state heat transfer, types and design of heat exchangers, electric conductivity of foods, Mass transfer and mass-heat-momentum transfer analogies. Dimensional analysis. Mathematical modelling and simulations.

Unit-6: Preservation Processes

Processing systems i.e. pasteurization and blanching systems, commercial sterilization systems, ultra-high pressure systems, microbial survivor curves, influence of external agents, thermal death time, spoilage probability, general method for process calculation, mathematical methods . Ohmic heating, microwave heating. Drying systems: superheated steam drying,

refractance window drying, heat pump drying, freeze drying, spray drying, foam bed drying, microwave drying, instant pressure drop (DIC) drying and hybrid dryingsystems.

Unit-7: Refrigeration and Freezing Systems

Selection of refrigerant, components of a refrigeration system, pressure-enthalpy charts, mathematical expressions useful in analysis of refrigeration systems. Food freezing systems i.e. indirect-contact and direct-contact systems, frozen-food properties, freezing time, frozen-food storage, suitable packaging and supply chain systems. Concept of Ice silos, centralised distribution of ammonia through pump, PUF panel design. Vapour absorption refrigeration system: Ammonia-water system, lithium bromide - water system. Heat Pumps: different heat pump circuits; analysis of heat pump cycle; Use of heat pumps in processing plant. Factors affecting performance and energy efficiency of refrigeration plants, energy saving opportUnities,

Unit-8: Evaporation and Concentration

Boiling point elevation, types of evaporators i.e. batch-type pan, natural circulation, rising-film, falling-film, rising/falling-film, forced-circulation, agitated thin-film evaporators etc; design of single and multi-effect evaporators; design of TVR and MVR, design and selection of evaporator pumps; design and selection of heat-exchanges; vacuum pumps; piping and instrumentation diagrams; heat and mass balance; vapour recompression systems; crystallizers and concentrators. Size enlargement. Encapsulation. Powder production system.

Unit-9: Processing Equipment Design

Pre-milling/conditioning treatments. Process technology and machinery 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, high pressure processing, Ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nanoencapsulation of food ingredients, Food nanotechnology, Seed processing and technology, Agricultural byproducts/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. Computer aided design and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selectionof standard parts (pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses). Mechanized manufacturing of indigenous food products.

Unit-10: Instrumentation and Process Control

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).

Unit-11: Food Safety Engineering and Ecosystem

Overview of food microbiology: Foodborne illness, food spoilage, food fermentation, microbiological physiology and food preservation, microbiological analysis, safety management systems. Overview of foodborne pathogens: Bacterial pathogens, food borne viruses and parasites. water and sanitation, GHP, GAP, HACCP, food allergies, Food Adulteration, Food Nutrition and Food Consciousness, Supplementation, Fortification, Bio-fortification, Genetically Modified Foods, CIB & RC, GEAC, Food testing and rapid detection methods, Accuracy and Precision in food testing. Process-dependent microbial modeling: Predictive microbial kinetic models, Temperature- dependent microbial growth kinetic models, Irradiation-dependent microbial growth model, Pulsed electric field- dependent microbial growth model, High-pressure-dependent microbial growth model; Process modeling; Integration of process and microbial growth kinetic models. GMP, Auditing and inspections, Food Surveillance, Risk Analysis: Risk Assessment, Risk Communication and Management, Traceability and Recall of Food Products, Popular global cases of recall, Quality control of food at all stages of processing, Safety issues in food packaging materials, Sampling from a lot or process line, Non-destructive food qualityevaluation methods, Safety issues of processed foods available in market, Shelf life studies, Global trends in Food Safety Assurance: Codex, US Food and Drug Administration and FoodSafety at European Union, Harmonization of Food Safety Regulations. Indian Scenario of Food Safety: Food Safety and Standards Act, 2006 and its Background, The Food Safety and Standards Regulations (FSSR) 2011: Licensing and Registration, Schedule 4 requirements, Recent advances in Packaging and Labelling Requirements, Regulations related to Nutraceuticals and Foods for Special Dietary Uses, Provisions on Organic Food and Non- Specified Food/Food Ingredients.

Unit-12: Analytical Techniques and Process Quality Assurance

Destructive and non-destructive, and online and offline assessments of ingredients / products / packaging materials. Principles, components and application of online sensors and celebrations. Instrumentation and automated analytical systems i.e. chromatography methods and systems, calorimetry systems, thermomechanical analysis, etc. Plant sanitation. CIP. Relevant quality and management regulations and systems.

Unit-13: Resource Sustainability

Generation of steam, fuel utilization, electric power utilization, energy, water and plant environment. Aspects of energy management and auditing in processing plant. Monitoring, survey instrumentation and data collection: general audit instrumentation, Co2, temperature, pressure, fluid and fuel storage and flow, combustion gas composition, electrical and light measurement. Assessment of plant's electrical and thermal utilities and services. Energy saving opportUnities in plants.

37. Fruit Science

Eligibility: Ph.D. in Fruit Science/Floriculture and Landscape Architecture/Floriculture and Landscaping/Horticulture/Post Harvest Management/Post Harvest Technology/Vegetable Science/Plantation, Spices, Medicinal and Aromatic Crops.

Syllabus:

Unit-1: Tropical and Subtropical Fruit Production

Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, National and International scenario, national problems. eco physiological requirements, global warming and climatic variability on fruit production in India and global level. Asexual and sexual methods of propagation, recent advances in propagation, root stocks, planting systems, High density planting, crop modeling, precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of biofertilizers, role of bio-regulators, abiotic factors limiting fruit production. Stress effects on fruit physiology and development, influence of stress factors, strategies to overcome stress effects, Organic farming systems,soil health management in organic production and quality improvement in organic production of fruit crops. The NPOP, HACCP, IFOAM guidelines for organic production and certification. physiological and biochemical factors associated with abiotic stress, fruit crops suitable for different stress situations. Physiology of flowering, pollination management, fruit set and development, unfruitfulness, self-incompatibility and sterility. Physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, transport, storage and ripening techniques. Agri-Export Zones (AEZ), marketing and industrial supports.

Crops: Mango, Banana, Citrus, Papaya, Grapes, Guava, Sapota, Jackfruit, Jamun, Litchi, Avocado, Rambutan, Durian, Mangosteen, Longan and Dragon fruit.

Unit-2: Temperate Fruit Production

Importance of temperate fruits and nuts, origin and distribution, major species, rootstocks and commercial varieties of regional, National and International scenario, national problems, global warming and climatic variability on fruit production in India and global level. eco physiological requirements. Asexual and sexual methods of propagation, recent advances in propagation, root stocks, scion and inter stock relationship - graft incompatibility, planting

systems. High density planting, crop modeling, precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of biofertilizers, role of bio-regulators, abiotic factors limiting fruit production. Stress effects on fruit physiology and development, influence of stress factors, strategies to overcome stress effects, Organic farming systems, soil healthmanagement in organic production and quality improvement in organic production of fruit crops. The NPOP, HACCP, IFOAM guidelines for organic production and certification. Stress effects on fruit physiology and development, influence of stress factors, strategies to overcome stress effects Physiology of flowering, pollination management, fruit set and development, unfruitfulness, self- incompatibility and sterility, pests and disease management physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; Agri-Export Zones (AEZ), marketing, industrial supports and measures for import substitution.

Crops: Apple, Pear, Peach, Plum, Apricot, Persimon, Cherries, Currents, Strawberry, Kiwi fruit, Walnut, Almond, Pistachionut, Hazelnut and Peccannut.

Unit-3: Arid and Dry Land Fruit Production

Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, National and International scenario, national problems, eco physiological requirements. Characteristics features and major constraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, national problems. Asexual and sexual methods of propagation, recent advances in propagation, root stocks, planting systems, High density planting, crop modeling, precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of biofertilizers, role of bio-regulators and abiotic factors limiting fruit production.Stress effects on fruit physiology and development, influence of stress factors, strategies to overcome stress effects,Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management. Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action andpractical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology,

contingency planning to mitigate different stress situations, stability and sustainability indices. physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; Agri-Export Zones (AEZ), marketing and industrial supports and and measures for import substitution.

Crops: Aonla, Ber, Bael, Custard apple, Datepalm, Fig, Karonda,Pomegranate, Phalsa, Wood apple.

Unit-4: Growth and Development

Growth and Development- definition, concepts and principles, parameters of growth and development, growth dynamics, morphogenesis, eco-physiological influences on growth and development of fruit crops-flowering, fruit set, crop load and assimilate partitioning and distribution.Environmental impact on growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat Units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs.. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development. Phytohormones and growth regulators, root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards. Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production. Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage and molecular approaches in crop growth regulation.

Unit-5: Canopy Management in Fruit Crops

Canopy management and its importance, factors affecting canopy development, canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light and its interception and distribution in different types of tree canopies. Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion. Canopy management through plant growth inhibitors, training

and pruning and management practices. Rootstocks for management of tree vigour and trellising in fruit crops. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

Unit-6: Biodiversity and Conservation

Biodiversity and conservation; issues and goals needs and challenges; centres of origin of crops, present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India. Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and basecollections. Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/DUS test guidelines, botanical and pomological description of major cultivars androotstocks of tropical, subtropical and temperate fruits and nut crops. Germplasm conservation- in situ and ex situ strategies, on farm conservation; custodian farmers, field gene banks (FGB) and National Active Germplasm Sites (NAGs), problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage. Germplasm Exchange, Quarantine andIntellectual Property Rights: Regulatory, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV&FR Act.GIS and documentation of local biodiversity, Geographical indications, GIS application inhorticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

Unit-7: Breeding of Fruit Crops

Problems and prospects of fruit breeding, species and cultivars, cytogenetics, genetic resources, blossom biology of different fruit crops., breeding systems, quantitative genetical studies in fruit crops (variance, gene action, heritability, response to selection), breeding objectives, ideotypes. Breeding methods: introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses and biotechnological interventions. Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits etc.,evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits , recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, breeding for specific traits, resistance breeding

to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit, fast track breeding – marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing technologies.Achievements and future thrust in mango, banana, citrus, grapes, guava, papaya, litchi, pomegranate, pineapple, apple, pear, plum, peach, apricot, cherries, strawberry, kiwifruit, Nuts. Varietal improvement in minor fruit crops such as aonla, bael, ber, jamum, karonda and mulberry.

Unit-8: Biotechnology in Fruit Crops

Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture. Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture. Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis. Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro establishment of tissue cultured plants. Physiology of hardening - hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast cultureand fusion. Construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops. Introduction to Cisgenics, gene silencing, gene editing- CRISPR-Cas 9.

Unit-9: Smart Fruit Production

Protected cultivation and precision farming techniques in fruit crops. Quality fruit production under protected environment; different types of structures – Automated greenhouses, glasshouse, shade net, poly tunnels - Design and development of low cost greenhouse structures. Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture. GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra-modern wireless based drip irrigation network. Nanotechnology for smartnutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano- herbicides and nano-

pesticides. Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turn-key systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers etc.

Unit-10: Post Harvest Management

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration and transpiration.Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage: ventilated, refrigerated, MAS, CA storage, physical injuries and disorders. Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies and candies. Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards. National and international fruit export and importscenario and trends ; Statistics and India's position and potentiality in world trade ; export promotion zones in India and Government Policies.Scope, produce specifications, quality and safety standards for export of fruits viz., mango, banana, grape, litchi, pomegranate, walnut, apple andother important fruits. Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

38. Genetic & Plant Breeding

Eligibility: Ph.D. in Genetics & Plant breeding/Plant Breeding & Genetics/Plant Genetic Resources/Seed Science & Technology/Genetics/Plant Breeding/Economic Botany/Agricultural Botany/Botany/Molecular Biology and Biotechnology/Plant Molecular Biology/Plant Biotechnology/Plant Sciences.

Syllabus:

Unit-1:Fundamentals of Genetics and Plant Breeding

History of genetics. Cell structure, division and cell cycle. Mendelian inheritance. Linkage, its detection and estimation. Epistasis. Sex determination. Sex-linked, sex-limited and sex-influenced traits. Pre- and post-Mendelian concepts of gene, allelism and fine structure of gene. Split genes, overlapping genes, pseudogenes, oncogenes, gene families and clusters. Extra chromosomal inheritance. DNA - structure, function, replication and repair. Genetic code. Transcription andTranslation. Gene- enzyme relationship. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations. Transposable elements.

History of plant breeding. Sexual and asexual reproduction. Breeding methods in self- and cross- pollinated crops. Pureline, pedigree and mass selection. Backcross method, single seed descent, multilines. Population improvement methods. Synthetics and composites. Apomixes, incompatibilityand male sterility systems in plant breeding. Inbreeding and consequences. Heterosis – genetic basis.Hybrid breeding. Breeding clonal crops.

Unit-2: Crop Evolution, Botany and Breeding

Origin and evolution of crop species. Centers of diversity. Speciation and adaptation. Adaptation traits and their importance in breeding. Crop domestication. Distribution, classification, botany, genetics, and breeding of cereals (rice, wheat, maize, oats, barley, millets), pulses (pigeon pea, chickpea, other pulses-mung bean, urd bean, cow pea, lentil, rajma, horse gram, field pea), oil seeds (groundnut, soybean, castor and sesamum, rapeseed and mustard, sunflower, safflower), fiber crops (cotton, Jute, mesta and minor fiber crops), sugarcane, forage crops. Released varieties of crops.

Unit-3: Auxiliary Crop Breeding Methods

History of mutation breeding. Nature and classification of mutations. Mutagens and their effect. Mutation breeding methods and selection. Doubled haploidy. Biparental and multiparental mapping

populations. Breeding designer crops. Ideotype breeding. Participatory plant breeding. Organic plant breeding. Physiological breeding – resource use efficiency. Rapid generation advancement. Shuttle breeding. Speed breeding. Reverse breeding. Cis-genesis and trans-genesis.

Unit-4:Genome organization and Cytogenetics of Crop Plants

Ultrastructure of chromosomes, function and replication. Introduction to the plant genomes-nuclear,chloroplast and mitochondrial genomes. C-value paradox. Repetitive and unique DNA. Recombination and crossing over. Karyotype analysis. Banding techniques. In situ hybridization. Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids and their utility. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-breeding. Inter- and intra-genomic interactions. Hybridization barriers and remediation. Synthesis of new crop species, alien addition and substitution lines, Balanced lethal and chromosome complexes. Controlled introgressions. Genome organization and cytogenetics of important crop species-wheat, maize, rice, brassica, groundnut, cotton, and sugarcane. Cytogenetic techniques for gene location and gene transfer.

Unit-5:Quantitative, Population and Biometrical Genetics

Quantitative characters. Multiple factors inheritance and their genetic control. Analysis of generationmeans. Analysis of genetic variance – fixed and random models. Heritability. Types of selection. Average effects and breeding value, Selection intensity, Genetic advance, and genetic gain. Response to selection, correlated response. Hardy-Weinberg law. Changes in gene frequency. Random drift, mutation and migration. Linkage disequilibrium (LD). LD measures. LD decay. Genetic load. Polymorphism. Relation between relatives - variance and covariance. Inbreeding coefficient. Analyses of Population structure. Wahlund effect. F-statistics. Analysis of molecular variance. Estimation of gene effects and combining ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability analysis – models and biplots. Mating systems and mating designs – diallel, line x tester, North Carolina designs, Triple test cross. Analysis of covariance. Genetic correlations. Path analysis. Selection indices and index selection. Analysis of genetic diversity – quantitative and qualitative measures. D2analysis and cluster analysis. Hierarchical clustering. Multivariate methods – Principal component analysis.

Unit-6: Molecular Organisation of Genomes, Molecular Breeding and Biotechnological Tools

Various biochemical and DNA based markers and their classification. Methods of marker-based genotyping. Polymerase chain reaction (PCR). Primers and their design. DNA fingerprinting. Genetic diversity analysis, linkage mapping and QTL mapping. Mapping functions. Bulked segregant analysis. Fine mapping, map-based cloning and allele mining. Marker assisted selection – MABB, MARS, Genomic selection. Gene/QTL pyramiding. DNA sequencing techniques. DNA libraries. Genome sequence projects and sequence databases. Genome annotation. Single nucleotide polymorphism (SNP) – detection and genotyping. Structured association mapping, Candidate gene- based association mapping. Genome wide association studies, joint linkage and association mapping. Expression profiling techniques including sequencing based, hybridization based and PCR based approaches. Reverse genetics approaches such as activation tagging, transposon tagging,insertional mutagenesis, TILLING and ecoTILLING. in vitro mutagenesis. Somaclonal variation. Vectors, genetic transformation and transgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement. Genome editing including ZFNs, TALENs, CRISPR systems. Genetically modified organisms (GMO). Biosafety regulations for GMOs.

Unit-7: Plant Breeding for Stress Resistance and Quality

Type of stresses. Qualitative and quantitative resistance. Concept of climate resilience. Genetic, molecular and physiological basis of abiotic stress tolerance such as temperature (heat and frost), flood (submergence and waterlogging) drought and soil stresses (acidity, salinity, alkalinity, sodicity, metal toxicity, nutrient deficiency). Breeding for tolerance to abiotic stress. Genetic and molecular mechanisms of resistance/tolerance to biotic stresses. Gene-for-gene hypothesis. Acquiredand induced resistance. Host-pathogen interaction. Breeding methods and accomplishments in stress resistance breeding. Usage of biotechnological approaches for biotic and abiotic stress resistance breeding.

Important quality parameters in various crops. Their classification. Antinutritional factors. Genetic and molecular basis of quality. Breeding methods and accomplishments in quality improvement among various crops. Biofortification.

Unit-8: Plant Genetic Resources, PGR Regulatory System; Varietal Release and Seed Production

Primary, secondary and tertiary gene pools as source of novel genes. Plant exploration, germplasm introduction, exchange, conservation in situ and ex situ. Participatory conservation of PGR. Conservation in vitro. Evaluation and utilization of plant genetic resources. Core development. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights. Biodiversity Act. Plant Variety Protection and Farmers' Rights Act. DUS testing. Systems of variety testing, identification, release and notification. Types of seeds and seed chain. Maintenance breeding. Quality Seed production and certification.

Unit-9: Basic Statistics and Experimental Designs in Plant Breeding

Frequency distribution. Measures of central tendency, probability theory. Tests of significance. Correlation, linear, partial and multiple regression. Design of experiments- basic principles. Complete block designs – completely randomized design, randomized block design and split plot design. Incomplete block designs – Augmented design, Alpha lattice.

Unit-10: Breeding Horticultural Crops

Importance of horticultural crops. Origin, domestication and distribution of various vegetable, fruit and ornamental crops. Genetic systems in horticultural crops. Breeding methods and accomplishments in vegetable crops, including leafy vegetables, cucurbits, solanaceous crops, cole crops, root vegetables and other vegetables (pea, beans, onion, garlic and okra). Breeding methods and accomplishments in fruit crops such as mango, banana, citrus, papaya, sapota, pomegranate, pineapple and guava. Importance of apomixis in fruit crops. Breeding methods and accomplishments in ornamental crops.

39. Home Science

Eligibility: Ph.D. in Home Science/Community Science and other related subjects to Home Science.

Syllabus:

Unit-1: Human Nutrition, Health and Interventions

Macro and micro nutrients in human nutrition; Carbohydrates, dietary fibre, proteins, lipids, vitamins, minerals and water - requirements, sources, functions, digestion, absorption acclimatisation, metabolism and effects of deficiency and toxicity; Hormones (chemistry, metabolism, mechanism of action); Nucleic acid, molecular aspects of nutrient transport. Glucose homeostatic, glycaemic index, nutrient turnover; Energy Balance: Bioenergetics, energy expenditure, thermo genesis, regulation, requirement, BMR. Metabolism of hunger. Nutrients inter-relationship. Inborn errors of metabolism. Phytochemicals, antioxidants, prebiotics and probiotics, functional foods, genetically modified foods, nutraceuticals and health foods. Balanced diet. Establishment of Recommended dietary allowances. Meal planning: Normal nutrition: pregnancy, lactation, infancy, preschool age, adolescent, adult and old age. Materno-fetal nutrition: physiology and nutrient demands of mother-child dyad. Physical fitness and sports nutrition. Diet & nutritional therapy. Food allergies and intolerances, trauma and burns. Oral and preantral nutrition. Infection and immUnity. Eating disorders. Major public health and nutritional problems in India- Global nutritional problems: Nutrition in emergencies and natural calamities. Assessment of nutritional status: anthropometry (measurement techniques, Indices and cut-off points), biochemical, clinical and dietary assessment. Body composition analysis; National Nutrition Policy: current policies and formulation. National and International organization's programmes to combat malnutrition. Nutritional epidemiology: biostatistics, planning epidemiological studies for policy formulation. Public health aspects of human nutrition. Nutrition education: objectives, principles and importance. Nutrition Intervention: importance, methods, nutrition monitoring and surveillance. Nutrigenomics: scope and importance.

Unit-2: Food Science and Processing Technologies

Food: Physico-chemical properties, methods, merits and demerits of cooking. Food Chemistry: chemical properties of food. Sensory evaluation and consumer acceptability of foods by subjective and objective methods. Food fortification, enrichment and supplementation. Food additives and Preservatives. Anti-nutritional factors & Toxicants in

foods. Food quality: hygiene and sanitation, food-borne illnesses, infections and food poisoning; food adulteration and detection, food standards (FSSAI), laws & regulations for food safety, HACCP and good manufacturing practices (GMP). Post harvest losses, food spoilage and its causes. Food processing techniques: Principles and methods of food processing for different food groups : drying, concentration, freezing, cryogenic freezing, fermentation, irradiation, canning, sterilization, pasteurization, ohmic heating, bakery and confectionery; effects on nutritional value; food packaging and labelling. Storage of perishable and non-perishable foods, traditional and modern food storage. Role of FCI in public distribution system. Recent advances in food science and technology: micro, nano and ultra-filtration, membrane technology, hurdle technology. Processed and convenience foods. Food analysis:Techniques, principles and methods for nutrients, antinutrients and phytochemicals.

Unit-3: Apparel and Textile Science

Fibre polymer chemistry; structure property relationship of natural, manmade & synthetic fibers; Nano and micro fibers and their production; Fiber Blending; Bi-component and bi-constituent fibers; High performance fibres; Technical textiles; Textile quality analysis; fiber, yarn and fabric testing; apparel quality control; Product development, testing, economics, standards/specifications; National and International organization for standards; Principles of weaving; looms; basic, textured and decorative weaves; woven designs, peg plans & weaving calculations; specialty fabrics; Knitting- principles, classification and knitting machines; Non-wovens- types, properties, finishing, application and testing; Chemistry of dyes and pigments; advanced dyeing and printing techniques; natural dyes; dyeing parameters; Colour science and theories of dyeing;Colour measurement systems; Whiteness, yellowness, brightness and fastness of colour; Computer colour matching; Textile finishes- scope, importance and classification; Surface active agents; Dyeing, printing and finishing auxiliaries; Traditional textiles, costumes and accessories of Egypt, Greece, Rome, France, Japan, America and China. Aspect of Functional clothing and clothing comfort; Heat transfer,clothing systems for thermal insulation and protection; Designing functional clothing for special needs and various occupations; sports and impact protective clothing.

Advanced techniques of pattern making and draping; Principles and techniques of contouring, pattern grading and fitting; Textile ecology; Eco-balance, eco textiles and sustainability; Indian and International environmental legislations; Eco labeling, management and auditing; treatment and disposal of textile effluents; Textile conservation- examination,

damage causing agents, condition, assessment, repair and stabilization of textiles, materials and equipment; Principles of cleaning; storage and display of fragile textiles.

Socio-psychological, health and sanitation aspects of clothing, Consumer behavior and marketing concept in relation to fashion and clothing; Development, status, classification, infrastructure & managerial techniques of Indian textile and garment industry; cost and productivity analysis; automation, use of CAD/CAM and robotics in textile industry; Merchandising, positioning and branding; Production and operations management in textile and apparel; Plant location, material handling and work study; Government initiatives on various apparel and textile sectors and EXIM policies

Unit-4:Human Development and Family Studies

Theoretical framework and critical review of different theories of human development-classical, contemporary and life span theories; Basic concepts and issues of human development-psycho-social perspective, Ecological modeling-physical, economic, socio-cultural and socio-political role of ecology in life course development; Current and classic research trends in human development and family studies; Models of intelligence and early brain development; Adolescent development and challenges;Developmental assessment-concepts,functions,characteristics and methods; Developmental tests and scales-types of measurement scales, standardization procedures, validity, reliability and ethical issues in the assessment; Need and scope of innovative programmes in early childhood development and education; Current innovative programmes at State, National and International level; Differently abled- etiology, developmental characters, classification, statistics, educational provisions, vocational interventions and government support services; Developmental intervention-theoretical frameworks and intervention models; Vulnerability, resilience, risk and protective factors; Guidance and counselling- meaning, history, goals, levels, techniques, areas, types, approaches and theories; Adulthood-developmental and theoretical perspectives; Gender studies- issues,gender discrimination indicators and gender development index; Family- theoretical framework, perspectives, transitionsand socialization; Parent child relationships- functional and dysfunctional dyads, models of parenting; Family stressors and resilience- impact of consumerism, emigration and multiculturalism;Cross-cultural variations in family functioning- theories and issues; Marriage- legal provisions, laws, adoption, divorce and inheritance; Family therapy- orientation, theoretical perspectives, types, concerns and prospects; Mental health– theories, issues, disorders, programmes, policies, behaviour assessment and modification.

Unit-5: Family Resource Management and Consumer Science

Management-Significance, scope, theories and functions; Management principles; Managerial skills and roles; Management process. Organizational behaviour: Values Attitudes and performance; Decision making-Models of decision-making behaviour; Leadership-characteristics; styles; theories and types: Conflict resolution strategies and management; Managerial ethics and social responsibilities; Motivation- importance, contemporary theories of motivation; Effect of interior design on user comfort- residential, commercial and special needs; Functional and aesthetic consideration in the use of elements and principle of design; Recent developments in building bye-laws; energy efficient buildingdesign; Green building design; Energy efficiency building regulations; Policies and institutional support for people with special needs. Consumer behaviour; Factors affecting buying behaviour; Models of consumer behaviour; New economic policies-liberalization, privatization, globalization; Consumer services- citizen charter, GST; Budget and economy; Methods of measurements of national income; National income and Economic welfare Taxation; Inflation and Deflation-meaning, types, causes, effects; Measures to control; Difference between global and international market; Gender issues in consumerism; Green Consumerism- meaning, objectives and need; Consumer protection measures- legal and non- legal consumer legislation; Trends and impact of advertising on consumers; Legal and ethicalaspects of advertising in India; Women's economic, social and cultural rights; National and International initiatives for women's economic empowerment; Effect of technology on environment; Global environmental issues and challenges- climatic change, global warming, population, land degradation, exploitation of natural resource, ozone depletion, acid rain; nuclear power; oil spill pollution, dumping of hazardous waste. Environmental Management System- carbon credit, environment standards, Environmental waste management; Energy policy of India.

Unit-6: Occupational Ergonomics

Ergonomics- Definition, aim, objectives and scope; Anthropometry and Biomechanics in ergonomics and design; Body movement and posture; Work physiology; Application of biomechanics to movement- qualitative and quantitative approach; Introduction to components of worker input- affective, cognitive, temporal and physical; Principles of workstation and system design; Design and arrangements of different work centres; Product design; Design consideration in product design for people with special needs. Workplace risk factors and hazards- types, source and classification; Tools and techniques for identifying risk factors

related to forceful exertion and repetitive motions; Postural discomfort and its impact on human health; posture analysis tools; Work related musculoskeletal disorders. Physical work capacity and workload measurement; Ergonomic task analysis; Methods for integrating ergonomics into existing occupations; System approach to ergonomics; Visual ergonomics and its advantages; Effect of environmental parameters on work, worker and work performance and its management.

Unit-7: Extension Education and Communication Management

Fundamentals of Extension education; Indian Extension systems – ICAR, Ministry of Rural Development, Ministry of Agriculturc and Farmers' Welfare, NGOs; Rural development programmes in India before and after independence; Paradigm shift in extension approachcs and systems; Recent trends in extension; Extension management and training organisations and institutions; Diffusion and adoption of innovations; Development communication; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs); Role of ICT in commUnity education: new media and multimedia; Transfer of Technology: forms, models and process of technology transfcr, Technology development and management process, Technology assessment and refinement; Communication process and skills: verbal, non vcrbal and written communication; Scientific communication: Formats of scientific writing, Writing for scientific journals and ratings of journals; Participatory programmemanagement, Project management techniques, Monitoring and evaluation of extension programmes; Educational technology : concept, teaching learning process, styles and strategies; ICT application in education; Group dynamics and management; CommUnity Development and outreach: concept principles and approaches; Organisational development and HRD mechanism: processes and outcomes; Mobilization and empowerment;Gender sensitization for empowerment; Gender issues and toolkit for assessment; Concept of climate and climate change, Greenhouse gases and global warming, Impacts of climate change, Climatc change policies in India; Concept, process and functions of management ; Skills for effective management of extension activities and organizations; Strategic planning; Management by Objective (MBO); Unified Talent Management (UTM); Self-Directed Micro Learning (SDML); Total Quality Management (TQM); Management of information system; Creativity and problem solving, motivational skills; Impact assessment of developmentprogrammes; Research methodology in extension and communication: Research designs, Sampling techniques, Tools of research; Scaling techniques for behaviour research: Levels of measurement, Techniques of scalc construction- Likert scale, Thurston scales, Measurement of

reliability and validity of scales; Sustainable development: Concept, principles, indicators and dimensions; Sustainable livelihood systems; Extension research project management: concept, models, approaches and tools; Media application and product promotion: Online andofflinc promotional strategies.

40. Land & Water Management Engineering

Eligibility: Ph.D. in Soil and Water Conservation Engineering/Soil and Water Engineering/Irrigation and Drainage Engineering/Irrigation Water Management Engineering/Water Science and Technology/Land and Water Resources Engineering/Aquacultural Engineering.

Syllabus:

Unit-1: Fundamental Concepts

Physical properties of soils, soil infiltration characteristics, hydraulic conductivity. Soil moisture content and soil water potential. Types of soil water, field capacity, wilting point, permanent wilting point and plant available water. Classification of land capability and soil irrigability. Movement of water within soils. Water movement through soil-plant-atmosphere system. Reference ET and crop ET, concepts of energy balance approach and its components, energy balance models for estimation of crop ET, ET-yield relationships. Management allowable deficit, effective rainfall. Water conveyance, application, storage and distribution efficiency. Irrigation water requirement, irrigation frequency, irrigation period, irrigation intensity. Delta and base period of crops, duty of water. Irrigation system capacity estimation, irrigation scheduling techniques. Classification of irrigation projects *viz.* major, medium, minor and micro. Land leveling design methods. Net positive suction head and cavitation, vapour pressure, water hammering problem in centrifugal pump. Pump characteristics. Design, operation, selection and maintenance of pumps for irrigation and drainage. Drivers ofclimate change, characteristics of climate system components *viz.* Greenhouse effect, carbon cycle, wind systems. Water related adaptation to climate change and mitigation strategies. Potential water resource conflicts between adaptation and mitigation.

Unit-2: Watershed Hydrology and Reservoir Operation

Hydrologic cycle, spatial and temporal scales. Hydrologic measurements and networks. Analysis of discrete and continuous hydrologic data. Precipitation mechanisms, types, spatial and temporal variation, design storm. Infiltration process description, infiltration indices, measurement, modelling *viz.* Horton model, Green-Ampt model, Kostiakov's and Philip's models, SCS model, Richards equation. Evaporation and evapotranspiration process description, measurement and estimation. Hortonian and saturation overland flow mechanisms, factors affecting base flow. Runoff estimation: Rational method, SCS-CN method. Hydrograph analysis: UH theory, IUH and GIUH. Watershed characteristics and their role in watershed management, morphometric analysis of watersheds. Watershed

modelling, classification of hydrologic models, discrete and continuous simulation models. Hydrologic design: Commonly used distribution functions in hydrology, parameter estimation, uncertainty concepts, first order reliability method (FORM), risk based design of water resources projects. Types of droughts, characterization of environment for water availability. Drought indices.

Reservoir flood routing, channel routing *viz.* Muskingum-Cunge method, Diffusion wave routing. Principles of integrated river basin planning and management. Water resources planning in river basins. Deterministic river basin modeling. Stream flow estimation, zones of storage in reservoirs, estimating reservoir storage capacity and safe yield, mass diagram analysis, sequent peak analysis, single and multi-reservoir operation models. Conflicts in (space/time/discharge) reservoir operation. Reservoir operation techniques *viz.* standard linear operating policy, concept of storage zoning, rule curves, system engineering techniques.

Unit-3: Soil Erosion Processes and Sedimentation

Soil erosion types and mechanics. Water and wind erosion mechanics and forms. Soil loss measurement. Biological measures for soil and water conservation. Design of bunds, terraces and vegetated waterways. Gully and ravine reclamation. Design of wind breaks and shelter belts, and stabilization of sand dunes. Rate of sedimentation, silt monitoring and storage loss in tanks and reservoirs. Concept of trap efficiency, estimation of life of reservoirs. Design of soil and water conservation structures like check dams, gully plugs, gabion structures, earth dams, silt detention dams and farm ponds. Soil loss estimation methods/models. Criteria of selection of appropriate structures as per soil, land use and climatic conditions. Hydraulic jump and energy dissipators for soil conservation structures. Cost economics of watershed development projects and their impact assessment.

Unit-4: Flow through Porous Media and Groundwater Processes

Theory of saturated and unsaturated flow in porous media. Concepts of homogeneity and heterogeneity. Governing differential equations *viz.* analytical and numerical solution of differential equations, initial and boundary conditions. Dupuit-Forchheimer theory and its limitations. Mechanisms of solute transport in porous media.

Types of aquifers, their properties. Principles of groundwater flow. Interaction betweensurface water and groundwater. Natural and artificial groundwater recharge. Conjunctive use of surface and groundwater. Derivation of hydraulics of fully and partially penetrating wellsin confined, leaky and unconfined aquifers. Flow net analysis. Analysis of well interference and multiple well systems. Pumping tests for estimation of aquifer parameters. Hydraulics of pumping wells near recharge and impermeable boundaries. Skimming well technology.

Design of open and tube wells. Salt water intrusion in inland and coastal aquifers.

Unit-5: Irrigation and Drainage Engineering

Canal irrigation management: Layout of canal irrigation systems, design of waterconveyance, control, distribution systems, outlets, irrigation efficiencies, canal roster and warabandhi, flow measuring devices, canal losses, lining of irrigation channels, economics of canal lining. Performance evaluation of irrigation systems. Farm water delivery system and control: Design of field channels and underground pipelines, water regulating and diversion structures. Farm irrigation system design: Types of farm irrigation systems, surface irrigation hydraulics, application methods and design, performance evaluation of surface irrigation systems-furrow, border and basins. Principles of sprinkler operation, uniformity coefficient, economic design of a sprinkler system, system design efficiency, trickle system components, water distribution in the soil profile, trickle system design, fertigation, and irrigation automation using IoT. Design of irrigation runoff recovery systems. Micro-climate-water- nutrient management in protected cultivation.

Water logging and soil salinization, classification of waterlogged and salt affected soils. Water quality criteria and brackish water use for agriculture. Drainage investigations, drainage requirements and crop growth under salt affected waterlogged soil, salt balance at farm level, leaching fraction. Drainage of irrigated land: Drainage problems, sources of excess water, drainage systems, planning, drainage coefficient, design of surface drainage system, design of subsurface drainage system, drain spacing under steady state, falling and fluctuating water table conditions, well drainage, mole drainage, bio-drainage, cost evaluation of drainage projects. Surface drainage performance and evaluation. Controlled drainage for reducing agricultural non-point pollution. Drainage materials. Disposal of drainage effluents.

Unit-6: Waste Water Management

Sources of contamination and characterization of urban and rural wastewater for irrigation. Water quality *viz.* physical, chemical and biological parameters of wastewater. Water quality requirement *viz.* potable water standards, wastewater effluent standards, water quality indices. Irrigation water quality standards and guidelines for their restricted and unrestricted uses. Selection of appropriate forestry trees, fruits, vegetables, oilseeds and food grain crop for wastewater utilization. Control measures for preventing soil and other surface/groundwater source contamination. Different types of wastewater, pollutants and contaminants. Impact of wastewater on ecosystem, eutrophication, bio-magnification, water borne diseases. Wastewater treatment methods *viz.* physical, chemical and biological. General water treatments like wastewater recycling, constructed wetlands, reed bed system. Carbon foot

prints of wastewater reuse. Conjunctive use of surface/groundwater with treated waste water for irrigation.

Unit-7: Tools and Techniques for Land and Water Resources Management

Remote sensing and GIS: Electromagnetic spectrum. Energy interactions. Platforms and remote sensing sensors: photographic camera, scanners, earth resources satellites, active and passive sensors. Spectral properties of a few common earth features, basic photogrammetry concepts. Digital image fundamentals, digital image processing: image rectification, image enhancement, image classification techniques and accuracy. Image interpretation. Geographic information system (GIS). Map projections and coordinate systems. GIS data formats: vector and raster data. GIS data input like digitization, remote sensing, field data and GPS. Spatial analysis like vector and raster analysis, measurement, query, statistical surfaces (DEM), network analysis. Accuracy and errors. Application of RS and GIS in land and water resource monitoring and management.

Sensors and AI: Principle of working of different types of soil moisture sensors, their calibration, automated irrigation scheduling using different sensors and data transmission techniques. Application of drones, Wireless Sensor Network (WSN) and microcontrollers for crop condition monitoring. Sensors for measurement of flow in pipe and open channels. Sensors in hydrologic monitoring stations and data transfer using telemetry. Artificial Intelligence (AI) tools and techniques, application of AI tools in modelling hydrologic processes and irrigation water requirements under changing climate. Use of AI tools and geospatial techniques in development of Decision Support Systems in management of land and water resources.

Unit 8: 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. Mann Kendall and Sen Slope tests for trend analysis.

41. Livestock Production and Management

Eligibility: PhD in Livestock Production & Management.

Syllabus:

Unit-1: General

Development of livestock industry, its present status and future prospects in India and world. Domestication and adaptation of livestock in different agro-climatic zones. SWOT analysis of the livestock sector. Livestock production systems in vogue under Indian conditions and world. Various livestock development programs in India. Biotechnological interventions for livestock improvement. Organic livestock production. Integrated farming system.

Unit-2: Breeding Management

Breeds/ strains of cattle, buffalo, sheep, goat, pig, yak, mithun, horse, donkey, camel, dog, cat and laboratory animals with emphasis on economic importance. Basic principles of inheritance. Concept of heritability, repeatability and selection. Methods of selection and systems of breeding in farm animals. Role of crossbreeding in evolving new breeds. Traits of economic importance and their inter-relationships. Database management and application of breeding related software. Recent advances in breeding management.

Unit-3: Feeding Management

Nutrients and their function. Nutritional requirement, formulation and compounding of ration. Various feeding standards. Feed and fodder resources for livestock, wild life and laboratory animals. Feed and fodder requirements of different categories of livestock, wild life and laboratory animals. Scientific technique and regimen of feeding and watering of different categories of livestock and laboratory animals. Supply of green fodder round the year. Enrichment of poor quality roughages. Non-conventional feeding resources. Pasture management. Feed supplements and additives. Least cost ration formulation and feed conversion efficiency. Storage, conservation and preservation of feeds and fodders. Recent approaches in feeding, phased feeding and eco-feeding. Hydroponic fodder. Feeding of agro-industrial by-products. Standards of drinking water, water hygiene and efficient water usage mechanisms.

Unit-4: Reproduction Management

Reproductive systems of farm animals. Heat detection and early pregnancy diagnosis methods. Causes, prevention and management of anestrus, infertility, sterility and calving difficulties. Optimizing age at first calving and calving interval. Improving breeding efficiency of livestock. Recent approaches in breeding and reproductive management of livestock. Optimization of reproductive traits. Artificial insemination. Recent advances in reproductive biotechnologies; MOET, cloning, estrus synchronization, sexed semen, IVF.

Unit-5: Livestock and Environment

Weather, climate and environment. Adaptation and acclimatization of livestock. Livestock and global warming. Agro-climatic regions of India and livestock performance. Climatic stress in livestock (heat stress/ cold stress); effects, measurement and amelioration. Temperature-humidity index and thermo-neutral zone. Micro and macro environment. Micro- climate modification in animal houses. Effect of climate change on animal production. Climate-resilient livestock production systems. Effects of Natural disasters on livestock and mitigation measures. Water, carbon footprints and carbon sequestration of farm animals and products. Mechanism and opportUnities of carbon trading in the livestock sector. Assessment of livestock impact on environment in different production systems. Farm animal, slaughter house and tannery waste. Strategies for mitigation of methane emission from the livestock sector. Selection for heat tolerance. Recent advances in shelter management under impendingclimate change.

Unit-6: Housing Management

Housing systems and standards (BIS) for livestock. Equipment requirements for different classes of livestock farms. Layout plans and construction details for different sized livestock farms in various agro-climatic zones of India. Advances in housing management related to design, layout, construction materials, cost of construction, climate resilience, heat & cold stress and behavior & welfare of animal. Low-cost animal houses. Ideal shelter management practices for better productivity. Advances in manure, waste and carcass disposal and utilization.

Unit-7: Livestock Behavior and Welfare

Evolution, importance and theories of animal behavior. Favorable and un-favourable behaviour of domestication. Behaviour assisted animal management. Behaviour based

housing designs. Vices and stereotypes. Social hierarchy and aggression. Species-specific behavior in relation to season and physiological condition for better productivity and welfare. Animal welfare, rights and freedoms. Indicators of animal welfare. Welfare of livestock in commercial farms and captivity. Environmental enrichment. Welfare of livestock during various management activities like handling, transportation, etc. Legislation and regulations of animal welfare. Evaluation of animal welfare measures as an 'instrument' of good animal husbandry, production of quality products and enhanced income to farmers.

Unit-8: Herd Health Management

Symptoms of ill health. Prevention and control of important infectious diseases. Hygiene and sanitation of livestock farms. Vaccination schedules. Internal and external parasites and their control. Common disinfectants used in livestock farm. Foot bath, dipping & wheel dip. Concept of first aid. Segregation and quarantine management of animals. Quarantine act for zoonotic diseases. Labour health programme. Bio-safety and security measures. Recent advances in herd health management.

Unit-9: Livestock Farm, Laboratory & Companion Animals, Wild Life and Zoo Management

Routine management practices (general, housing, feeding, breeding, cleaning) and labour management of livestock, laboratory& companion animals, wild life and zoo for different categories of animals. Conservation of indigenous germplasm. Animal judging. Body condition score. Establishment of Livestock Enterprises of different sizes for various economic strata. Advances in livestock management. Transportation for various purposes. Milking management & clean milk production. Sanitary and phytosanitary standards for the production of quality milk. Draughtability and advance management of draught animals. Salvaging of buffalo calves. Small ruminants' management; production systems, prospects under stall feeding, slaughter management (methods, carcass traits, by-products). Swine production; production systems, slaughter management (methods, carcass traits, dressing %, by-products). Equines; ownership, foot and dental care, training, exercising, doping, regulatory acts in disease control and welfare, race clubs, transportation, import and export. Companion animals; ownership, training, preparation of animals for show, judging, kennel clubs, hostels, parks, licensing. Wild life management; taxonomy and distribution of important Indian wild animals and birds, ecology of wildlife sanctuaries and National parks, principles and concepts of zoo and captive wild animals, status of forest in India, biological and ecological basis of

management of wildlife, rules and regulations of Zoo Authority of India, wildlife protection act, conservation of wild animals, wildlife movements & human- animal conflict, refuge rehabilitation. Laboratory animals; production of laboratory animal models (SPF, gnotobiotic, germfree).

Unit-10: Precision Livestock Farming

Precision Livestock Farming; scope and limitations. Animal identification and tracking. Sensor systems and ICTs in animal health, productivity and welfare. Use of virtual fencing, GPS and GIS in precision livestock faming. Early warning systems for animal health and welfare. Livestock farm machineries with their functions; Tractor& trolley, scraper, milking machine, mower, field chopper, chaff cutter, fogger, mister, sprinkler, forage harvester,mechanical hay drier, conventional baler, hay stacker, straw combine, sewage and water pump, electrical switch & gears, feed plant machines, weighing bridge, automatic feeder and waterer, milk storing equipment, shearing machine, TMR and CFB machine. Use of non- conventional energy at livestock farm. Application of robotics in livestock. Software for database management, computation and analysis.

Unit - 11: Entrepreneurship in Livestock Sector

Management principles. Factors of production. Livestock production economics; supply and demand. Cost of production. SWOT analysis for different livestock species. Profit maximization. Livestock marketing; newer concepts, advertising research, market surveillance. Marketing channels and laws. Pricing strategies& supply chain management. Livestock entrepreneurship; concept, characteristics, role in relation to enterprise, functions, limitations. Process and criteria of entrepreneurship development in livestock sector (techno-economic feasibility of enterprises, training and management skills, business acumen, business communication, inter-personnel skills etc.). Institutional interface in the development of entrepreneurship, incubation centres, startups, PPPs in the livestock sector. Entrepreneurial training/ development programmes at the State and National level. Livestock Insurance. Financial credit and management. Bank and Government support for entrepreneurship. Analyzing project; appraisals and reports, capital, expenditure decisions, reinvestment and payback. Preparation of bankable projects and profit assessment.

42. Livestock Products Technology

Eligibility: Ph.D. in Livestock Products Technology/Dairy Technology/Dairy Engineering/Food Science and Technology/Food Technology.

Syllabus:

Unit-1: Meat Production and Abattoir Practices

Meat production trends in India - Sustainability issues - Government policies and strategies for augmenting meat production, male buffalo calf, non-conventional meat resources - Handling and transportation of meat animals and poultry - Slaughterhouses and processing plants in India – Establishment and operation of a modern abattoir - Legislations and regulations - Advances in mechanization and tools of slaughter house and poultry processing plants - Ante-mortem inspection - Stunning - Slaughter and dressing - Post-mortem inspection - Automation/ Robotics in meat processing - Evaluation of carcass quality -Chilling and freezing of carcass - Maintenance of cold storages - Sanitation of slaughterhouseand meat plant.

Unit-2: Fresh Meat Technology

Genetic, nutritional and physiological aspects of muscle development - Ultra structure and chemistry of skeletal muscle - Modern tools for fibre typing of muscle - Myofibrillar, sarcoplasmic and connective tissue proteins - Cytoskeletal proteins - Chemical and biochemical aspects of Rigor mortis and fresh meat quality - Odour, colour, WHC, texture/tenderness, Defects during the conversion of muscle to meat - ageing/ conditioning of meat - Electrical stimulation - Carcass grading and fabrication - Artificial tenderization - Composition and nutritive value of meat - Lipid profile -Meat in human nutrition and health.

Unit-3: Processed Meat Technology

Current trends in meat processing - Basic principles of meat preservation - Functional properties - Latest meat processing equipments - Meat and non-meat ingredients and their roles - Cooking methods - New product development - Processing of emulsion based, enrobed, restructured/reformed, cured and smoked, dried, shelf-stable, fermented, intermediate moisture meat products -Indigenous, organic, ethnic and heritage meat Products

- Non-thermal processing including HPP and Irradiation - Thermal processing of meat - Canning/ retorting -Massaging, tumbling and flaking - Meat analogues and substitutes -

Enzymatic and non-enzymatic browning reactions, Protein changes in processed meat products - Lipid changes - Protein and lipid interaction - Protein and carbohydrate interaction - Bioactive peptides - Functional and designer meat products - Role of omega-3 fatty acids in animal Foods - Role of n-3 in PUFA enriched and CLA enriched meat and eggs -Developments in sensory evaluation of meat products.

Unit-4: Slaughterhouse By-Products Technology

Latest machinery and tools for by-product processing plants - New technologies for utilization of animal by-products as food, feed, pharmaceuticals and other miscellaneous products - Processing of animal by-products for pet foods - Leather chemistry and processing technology - Latest Techniques in handling, manufacture and testing of leather - Value addition in leather processing - Developments in gelatin, glue and natural casings production

- Characterization, processing, yield and quality control of rendered fat and meat cum bone meal - Organization, layout and operation of dry and wet rendering plants - Handling,disposal and condemnation of unfit materials - Latest trends in the disposal of solid and liquidwaste from meat processing plants and control of environmental pollution - Designs, layout and function of effluent treatment plants - State and Central Pollution Control Board norms.

Unit-5: Milk and Milk Products Technology

Principles and practices of production of quality raw milk - Dairy plant organization and operation - Advances in methods of chilling of milk - Thermal processing of milk - Principles, methods and types of UHT processing plants - Rheology of milk products - Composition, nutritional, physico-chemical and functional properties of milk - A1 and A2 milk and their significance - Physical, chemical and nutritional effects of processing on milk -Novel and indigenous milk products - Preservation of milk products - Application of immobilized enzymes in dairy products - New concepts in milk processing - Radiation, microwave processing and conduction heating of milk - Membrane processing technology - Indigenous, ethnic and organic dairy products - By-products from the dairy industry and their utilization - Latest trends in cleaning and sanitation of dairy plant - Disposal of solid and liquid waste from dairy processing.

Unit-6: Bio-technology and Quality Control of Livestock Products

Biotechnology in improving quality of Meat, Milk, Eggs and their products - Biotechnological tools for microbial testing of food - Bacterial food additives and

supplements - Characteristics and application of microbial starters in milk and meat fermentation - Biotechnology in production of designer livestock products - Bio-production of flavours and colour and their application in livestock products - Enzyme applications in dairy and meat industry - Utilization of nanotechnology in livestock products - Biotechnologyfor food safety - Cultured meat – Biotechnology in meat species identification.

Importance of quality control for livestock products - Microorganisms associated with contamination and spoilage of Meat, Milk, Eggs and Fish - Control of microbial growth in livestock products - Antimicrobial resistance - Residues in livestock products - Differentlegal and voluntary standards for milk, meat, eggs and their products - Concept and application of HACCP, BIS, FSSAI, AGMARK, ISO and Codex standards - Good Laboratory Practices (GLP), Good Hygienic practices (GHP) and Good Manufacturing Practices (GMP), Sanitary and Phytosanitary measures (SPS), Food Safety System Certification (FSSC) and total quality management in the processing of livestock products. FSSAI Standards for milk, meat, egg and fish and their products.

Unit-7: Egg, Wool and Fish Technology

Structure, composition, nutritive value and functional properties of eggs - Grading of eggs - Lay-out and organization of egg breaking and processing plants - Preservation methods viz pasteurization, freezing, dehydration, etc. - Designer egg and egg products. Wool types - structure of wool fibre - Physical and chemical properties of wool - Grading of wool - Specialty hair fibres - Testing of wool - Processing of wool - By-products of wool industry. Fishery resources, marine and freshwater fishes - Transportation and hygienichandling of fish - Fish Muscle structure, composition and nutritive value - Processing and preservation of fish - Surimi and other Fish based products.

Unit 8: Packaging and Marketing of Livestock Products

Packaging materials and their characteristics - Different packaging systems for milk, meat, chicken, eggs, fish and their products - Active and intelligent/ smart (biosensors) packaging - Edible and biodegradable packaging - Nanotechnology for food packaging - Advances in the packaging of livestock products - Labeling requirements and regulations for different livestock products-Recycling of packaging materials. Marketing of Livestock Products - Types of markets - Marketing channels of live animals, meat, milk, poultry, eggs and fish - On-line marketing - Value Chain management and strategies and interventions - Traceability systems for different livestock products.

43. Nematology

Eligibility: Ph.D. in Nematology/Entomology/Plant Pathology/Agricultural Entomology/Zoology.

Syllabus:

Unit-1: History and Principles of Plant Pathology
Diseases caused by plant-parasitic nematodes-symptomatology, biology, distribution and management of plant parasitic nematodes of economic importance (Pratylenchus, Radopholus, Hirschmanniella, Meloidogyne, Heterodera, Globodera, Rotylenchulus, Tylenchulus, Ditylenchus, Anguina, Aphelenchoides, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Scutellonema, Paratylenchus, etc.). Entomopathogenic nematodes.

Unit-2: Laboratory and Analytical Techniques
Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny and systematics. Classification of soil and plant -parasitic nematodes and their relationships with other related phyla. Detailed classification of plant - parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes. Various systems: digestive, excretory, nervous, reproductive etc., developmental biology of nematodes.

Unit-3:Physiological and Molecular Plant Pathology
Methods of extraction of nematodes from soil and plant material. Microscopy -principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology and culturing of nematodes - plant parasitic, entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics. Techniques for mass culturing of nematode antagonistic bioagents.

Unit-4 : Nematode Ecology
Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modeling. CommUnity analysis.

Unit-5 : Plant Nematode Relationships

Types of parasitism in nematodes. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved. Pathotypes in nematodes. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections. Physiological, biochemical and molecular changes in plants due to nematode infections is covered in PhD..

Unit-6 : Nematode Physiology and Cytology

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of muscular, nervous and sensory responses. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Nematode as biological models - Caenorhabditis elegans. Cytological changes in plants due to infection including syncytia, giant cell formation and their modification etc.

Unit-7: Nematode Management

Principles and methods of nematode management - physical, cultural biological, chemical and legislative, Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Integrated nematode management. Role of biotechnology in nematode management.

Unit-8: Interactions of Nematodes with Soil Organisms

Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

Unit-9: Statistics

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions: normal, binomial and poisson. Correlations: partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.

44. Plant Biochemistry

Eligibility: Ph.D. in Plant Biochemistry/Agricultural Biochemistry/Biochemistry/Chemistry.

Syllabus:

Unit-1: Basic Biochemistry and Biomolecules

Scope and importance of biochemistry in agriculture and allied sciences. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages. Cell organelles- structure and functions. Chemical bonding in biological systems. Structure and properties of water, acid base concept, pH and buffers. Thermodynamics and bioenergetics-concept of entropy and free energy changes in biological reactions, Role of high-energy phosphates. Classification, structure, chemistry, properties and functions of carbohydrates, proteins, lipids and nucleic acids. Biomembranes – structure and roles. Components of immune system.

Unit-2: Enzymology- Concepts and Applications

History, nomenclature, classification and general properties of enzymes. Mechanisms of enzyme action and active site mapping. Enzyme kinetics, inhibition, activation and regulation. Isoenzymes, ribozymes and abzymes, synzymes. Coenzymes and cofactors. Pseudoenzymes and extremozymes. Allosteric enzymes-structure, kinetics and regulation. Multi-substrate reactions- mechanisms and kinetics. Enzyme Promiscuity and bifunctional enzymes. Enzyme engineering-concepts and applications. Methods for extraction, purification and assay of enzymes. Immobilization of enzymes-methods and applications. Role of enzymes in food processing, pharmaceutical, diagnostic,paper and other industries.

Unit-3: Vitamins, Hormones and Phytochemicals

Structure, mode of action and biological functions of vitamins. Deficiency diseases associated with vitamins, Peptide and steroid hormones. Animal hormones- Structure, mode(s) of action and associated disorders. Physiological functions and metabolism of phytohormones: auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassinosteroids, and strigolactones. Basic chemistry of plant bioregulators like salicylic acid and methyl jasmonate etc. Structure, classification function and biosynthesis of plant secondary metabolites, viz., alkaloids, phenolics, terpenoids & steroids. Metabolism of cyanogenic glycosides and glucosinolates.

Unit-4: Intermediary Metabolism

Anabolism, catabolism and their regulation. Metabolism of carbohydrates- glycolytic pathway, HMP pathway, TCA cycle, glyoxylate pathway, gluconeogenesis and oxidative phosphorylation. Lipid metabolism- degradation and biosynthesis of fatty acids, ketogenesis etc. Biosynthesis of storage & membrane lipids and sterols. Amino acid metabolism -catabolism of amino acids, urea cycle,biosynthesis of amino acids, conversion of amino acids into bioactive compounds. Metabolism of nucleic acids – degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Transport of molecules and ions across membranes. Signal transduction mechanisms – roles of G-proteins, cyclic nucleotides and calcium in transduction. Inborn errors and disorders of lipid, carbohydrate, nucleic acid and amino acid metabolism.

Unit-5: Nutritional Biochemistry

Fundamentals of nutrition, concept of balanced diet. Biochemical composition, energy and food value of various food grains (including cereals, millets, pulses, oilseeds), fruits and vegetables. Physicochemical, functional and nutritional characteristics of macronutrients (carbohydrate, proteinsand lipids), micronutrients (vitamins and minerals) and phytonutrients in various foods and their significance in human health. Factors affecting bioavailability of nutrients in different food matrices.Interrelationship in nutrient functions. Antioxidants and nutraceuticals, prebiotics and probiotics, food additives, food toxins and anti-metabolites. Mineral deficiency diseases. Biochemistry of postharvest storage & preservation and effect of processing methods on the stability, functionality and bioavailability of nutrients. Food sensitivity- nature and properties of antigens in foods, mechanism of induction of allergic reactions. FSSAI rules and regulations.

Unit-6: Tools and Techniques in Biochemistry

Principles of optical, phase contrast, fluorescence and electron microscopy. UV- and VIS-spectrophotometry, fluorimetry, turbidometry and atomic absorption spectrophotometry. Centrifugation – principles of sedimentation, differential centrifugation, density gradient centrifugation and ultracentrifugation. Chromatographic techniques – paper, thin layer, gel filtration,ion exchange and affinity chromatography, GC, HPLC and FPLC. Electrophoresis – gel electrophoresis, isoelectric focusing, 2D-PAGE, pulsed field gel electrophoresis, immune-electrophoresis. Tracer techniques in biology: concept of radioactivity, radioactivity counting methods, scintillation counters and autoradiography. Mass spectroscopy- LC-MS, GC-MS, ICP-MS etc. General principles of yeast-two-hybrid (Y2H), MALDI-TOF, iTRAQ, ChIPSeq etc. and their applications in omics studies. Polymerase Chain Reaction (PCR), Southern,

Northern and Western blotting, ELISA, RIA, immunoblotting, Flow cytometry and Fluorescence-activated cell sorting (FACS), Imaging techniques. Microarray and DNA chips. Preliminary methods of statistical analysis

Unit-7: Plant Metabolic Processes

Photosynthesis–structure and chemistry of photosynthetic pigments, phytochromes, light reactions, photosystems. Carbon reduction in C3, C4 and CAM pathways, photorespiration, sucrose-starch interconversion and seed-reserve biosynthesis. Anoxygenic photosynthesis. Uptake and metabolism of mineral nutrients in plants. Nitrogen cycle, nitrate and nitrite reduction, ammonium assimilation, denitrification. Symbiotic and non-symbiotic biological nitrogen fixation-mechanism, regulation andsignificance. Chemoautrotrophy in rhizobia and nitrifying bacteria. Sulphur metabolism-sulphar chemistry and function, reductive sulphate assimilation pathway. Biochemistry of seed germination and fruit ripening. Molecular mechanisms of plant growth and development. Phytohormones and signal transduction pathways. Biosynthcsis of structural carbohydrates, oligosaccharides and storage proteins.

Unit-8: Basic and Applied Molecular Biology

Structure and properties of nucleic acids. Concept of genes and genome, Chromatin structure and function, Basic principles and mechanisms of replication, transcription and translation. Post- transcriptional and post-translational modifications. Replication of viruscs, mutagens, oncogenes and carcinogenesis. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eukaryotes. RNA editing, riboswitches and epigenetic control of gene expression. General organization of nuclear, mitochondrial and chloroplast genomes. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Genome sequencing technologies. Gene silencing technologies: virus induced gene silencing (VIGS), RNA interference (RNAi) etc. Genome editing tools -TALENs, ZFN, CRISPR/Cas, and their application. Bioinformatics tools in molecular biology.

Unit-9: Plant Biotechnology and Genetic Engineering

General principles of recombinant DNA technology. Isolation and characterization of plant genesand promoters. Methods of gene transfer-plasmid and viruses as vectors. Gene cloning, construction & screening of genomic and cDNA libraries. Cell, tissue and organ culture. Plant transformation

methods and molecular analysis of transformants. Transposon tagging and chromosome walking. Site directed mutagenesis. Applications of functional genomics, epigenetics, epigenomics, molecularmarkers and plant genetic engineering for crop improvement. Ethical, safety and Intellectual Property Rights (IPR) issues in plant biotechnology. Nanobiotechnology-concepts and applications.

Unit-10: Biochemistry of Biotic and Abiotic Stresses

Stresses and stressors – types, their effects on crop plants. Biotic stressors – molecular mechanisms of pathogen infection in plants. Plant defense response- role of plant secondary metabolites, antimicrobial molecules, genes for resistance, hypersensitive response, systemic and acquired resistance, pathogen derived-resistance. Plant viruses, host-virus interactions, viroids. Manifestation and alleviation of abiotic stresses- synthesis and roles of osmolytes such as proline, glycine betaine etc. in abiotic stress tolerance. Generation and roles of different reactive oxygen, nitrogen and sulphur species in biotic and abiotic stresses. Antioxidant molecules and enzymes in plants for defense. Molecular strategies for imparting tolerance to plants against biotic and abiotic stresses. Plant metabolism of xenobiotics- mechanism of detoxification and degradation. Strategies for phytoremediation.

45. Plant Pathology

Eligibility: Ph.D. in Plant Pathology/Agricultural Botany/Botany.

Syllabus:

Unit-1: History and Principles of Plant Pathology

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical development of chemicals, legislative, cultural and biological protection measures including classification of plant diseases. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection,colonization and development of symptoms.

Unit-2: Laboratory and Analytical Techniques

Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Molecular detection of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Laboratory equipment and their use: autoclave, hot air oven, laminar flow, spectrophotometer, electrophoresis, light and electron microscopy, incubator, ultracentrifuge, ELISA Reader.

PCR and Non-PCR based high-throughput diagnostic techniques, Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL), whole genome sequencing; Volatile compounds profiling by using GC-MS and LC-MS; FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors fordetection of plant pathogens

Unit-3: Physiological and Molecular Plant Pathology

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance. Phytoalexins. PR proteins. Antiviral proteins. SAR. HR and active oxygen radicals. Tissue culture. Somaclonal variation and somatic hybridization. Elementary genetic engineering. Management of pathogens through satellite, antisense RNA. Ribozymes, coat protein, hypovirulence cross protection/useful genes and promoter technology biosafety and bioethics. 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker- assisted selection.

History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen

relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions. Different forms of plant-microbe interactions and nature of signals/ effectors underpinning these interactions. Plant innatc immUnity: PAMP/ DAMP. Molecular basis ofhost-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction, virus induced gene silencing, Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of rcsistancc genes, Gene for gene systems molecular mechanisms, Co-evolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, durability of resistance, erosionof quantitative resistance. Pathogen population genetics.

Unit-4: Mycology

Classification of fungi, Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

serological, chemical molecular and numerical taxonomy. Phylogeny, Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. sex hormones in fungi, pleomorphism and speciation in fungi. Mechanism of nuclear and extra-nuclear inheritance, biodegradation, genetic improvement of fungal strains, fungi mediated synthesis of nano particles – characterization process and application, mycotoxins problems and its management.

Unit-5: Plant Bacteriology

Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in rclation to function. Growth curve, nutrition and auxotrophic mutants. Resting cells in prokaryotic, elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression: ar, her, vic and pat gencs. Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes. Spiroplasmas and Phytoplasmas, role of virulence factors in expression of symptoms, Variability among phytopathogenic prokarya, L form of bacteria Advances in classification and nomenclature, specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, pathogenicity islands, bacterial Pan-Genome. Qurum sensing, Bacterial pathogenicityand virulence, bacterial secretion systems, Role of hrp/ hrc genes and TALE effectors. Synthesis and regulation of EPSs, beneficial Prokaryotes-Endophytes, PGPR, Phylloplanc bacteria and their role indisease management. Endosymbionts for host defence.

Unit-6: Plant Virology

Nature, composition and architecture of viruses and viroids. Properties of viruses. Variability in viruses. Satellite viruses and satellite RNA. Assay of plant viruses including biological, physical, chemical, serological and molecular methods. Conventional and biotechnological techniques used in detection and diagnosis. Behaviour of viruses in plants including infection, replication and movement. Histopathological changes induced by viruses in plants, inclusion bodies. Transmissionof viruses: virus - vector relationships. Nomenclature and classification of viruses.

Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virusfree planting materials. virus genome organization replication, transcription and translational strategies, Phylogenetic grouping system based on partial/ complete sequences of virus genomes andusing of next generation sequencing technology in plant virus discovery. Classification, structure and functions of various domains of Immunoglobulins. Production of polyclonal and monoclonal antibodies for detection of viruses.

Unit-7: Plant Disease Epidemiology

Concepts in epidemiology. Development of disease in plant population. Monocyclic and polycyclic pathogens. Role of environment and meteorological factors in the development of plant disease epidemics. Survey, surveillance (including through remote sensing), and prediction and forecasting of diseases. Epidemic analysis and prediction models. Crop loss assessment: critical and multiple point models. Elements of epidemics and their interaction. Structures and patterns of epidemics. expert systems in plant pathology. Genetics of epidemics. Models development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics, image analysis

Unit-8: Phanerogamic parasites and Non-Parasitic Diseases

Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourablesoil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary airpollutants and acid rain.

Unit-9: Fungal Diseases of Crop Plants

Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices and ornamental crops with special reference to etiology, disease cycle, perpatuation,

epidemiology and management. Post harvest diseases in transit and storage; aflatoxins and their integrated management. Diseases of cash crops, fodder legume crops, Medicinal crops

Unit-10: Bacterial and Viral Diseases of Crop Plants

Crop diseases of cereals, pulses, oilseeds, vegetables, fruits, plantation and fiber cropscaused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and managemcnt. Discascs of cash crops, fodder legume crops, Medicinal crops.

Unit-11: Management of Plant Diseases

General principles of plant quarantine. Exotic pathogens and pathogens introducedinto India. Sanitary and phytosanitary issues under WT0, TRIPS and PRA. Geneticbasis of disease resistance and pathogenicity: gene for gene hyphothesis; parasite mediated frequency - dependent selection concept of QTL mapping; breeding fordisease resistance. Production of disease free seeds and planting materials.Seedcertification. Chemical nature and classification of fungicides and antibiotics:theirbioassy and compatibility with other agricultural chemicals; resistance to fungicides/antibiotics; effect on environment. Spraying and dusting equipments, their care and maintenances. Important cultural practices and their role in disease management, solarization, integrated disease management.Microorganisms antagonistic to plantpathogens in soil, rhizosphere and phyllosphere and their use inthe control of plantdiscascs; soil fungistasis. Plant growth promoting Rhizobacteria. Types of resistance disease escape, disease tolerance, hypersensitivity mechanisms, protein-for-protein and immunization basis, management of resistance genes. phytotoxicity of fungicidcs, pcrsistcncc, composite formulations of pesticides, issues related to label claim, mode of action and application ofdifferent chemicals, residues and health hazards, Important botanicals used against diseases and their mode of action. Types of losses caused by seed-borne diseascs in truc and vegetative propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens, Management of seed-borne pathogens, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents. Geneediting, role of ISTA, EPPO, OECD, etc. in certification and quality control. National Regulatory mechanism and certification, system including seed certification, minimum seed certification standards, role of seed/ planting material health certification in national and international trade. National Regulatory Mechanism and International Agreements/ Conventions, viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures, Biosafety, policies and regulatory mechanism.