

SYLLABUS FOR DOCTORAL DEGREE ENTRANCE EXAMINATION
(AGRICULTURE; HORTICULTURE & AGRICULTURAL
ENGINEERING) -2018

FACULTY OF AGRICULTURE:

1. AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

Concept of land, soil and soil science. Composition of earth crust and its relationship with soils; Rocks, minerals and other soil forming materials; Weathering of rocks and minerals; Factors of soil formation; Pedogenic processes and their relationships with soil properties; Soil development; Pedon, polypedon, soil profile, horizons and their nomenclature. Soil Taxonomy - epipedons, diagnostic subsurface horizons and other diagnostic characteristics, soil moisture and temperature regimes, categories of the system and their criteria; Interpretation of soil survey data for land capability and crop suitability classifications, Macro-morphological study of soils. Application and use of global positioning system for soil survey. Soil survey- types, techniques. Soil series- characterization and procedure for establishing soil series, benchmark soils and soil correlations. Study of base maps: cadastral maps, toposheets, aerial photographs and satellite imageries. Use of geographical information system for preparing thematic maps. Soil physical constraints affecting crop production. Soil texture – textural classes. Soil structure – classification, soil aggregation and significance, soil consistency, soil crusting, bulk density and particle density of soils and porosity, their significance and manipulation. Soil water- retention and potentials. Soil moisture constants. Movement of soil water - infiltration, percolation, permeability, drainage and methods of determination of soil moisture. Darcy's law. Thermal properties of soils, soil temperature, Soil air- composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil erosion by water- types, effects, mechanics. Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management, runoff farming. Soil conservation measures. Characterization and evaluation of soil and land quality indicators; Causes of land degradation; Management of soil physical properties for prevention/restoration of land degradation; Identification, monitoring and management of waste lands; Land use-land cover mapping and land use planning using conventional and remote sensing techniques; Concept of watershed – its characterization and management. Chemical composition of soil; Soil colloids - structure, composition, constitution of clay minerals, amorphous clays and other non-crystalline silicate minerals, oxide and hydroxide minerals; Charge development on clays and organic matter; pH-charge relations; Buffer capacity of soils. Elements of equilibrium thermodynamics, chemical equilibria , electrochemistry and chemical kinetics. Inorganic and organic colloids- surface charge characteristics, diffuse double layer theories, zeta potential stability, coagulation/ flocculation, peptization, electrometric and sorption properties of soil colloid. Soil organic matter-fractionation, clay-organic interactions. Cation exchange- theories, adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, anion and ligand exchange- inner sphere and outer-sphere surface complex formation, fixation of oxyanions , hysteresis in sorption-desorption of oxy-anions and anions. Nitrogen, potassium, phosphate and ammonium fixation in soils and management aspects. Chemistry of acid, salt-affected and submerged soils and management aspects. Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and transport of nutrients (Macro and micro nutrients) in soil; Manures and fertilizers; Fate and reactions of fertilizers in soils; Chemistry of production of different fertilizers; Slow release fertilizers and nitrification retarders; Quality control of fertilizers. Soil

fertility evaluation – soil testing, plant and tissue tests and biological methods; Common soil test methods for fertilizer recommendation; Soil test-crop response correlations; Integrated nutrient management; Use of isotopic tracers in soil research; Nature, properties and development of acid, acid sulphate, saline and alkali and their management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC and specifications. Fertility status of major soil groups of India. Pollution: types, causes, methods of measurement, standards and management. Heavy metal toxicity and soil pollution; Chemical and bio-remediation of contaminated soils; Soil factors in emission of greenhouse gases; Carbon sequestration in mitigating greenhouse effect; Radio-active contamination of soil. Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root-soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Soil characteristics influencing growth and activity of microflora. Microbial transformations of N, P, K, S, Fe and Zn in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. Humus formation. Cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures. Biofertilizers – definition, classification, specifications, method of production and role in crop production. Methods of soil analysis - particle size distribution, bulk and particle density, moisture constants, Modern methods of soil, plant and fertilizer analysis; Flame photometry and inductively coupled plasma optical emission spectroscopy; Spectrophotometry - visible, ultra-violet and infrared; Atomic absorption spectrophotometry; Potentiometry and conductimetry; X-ray diffractometry; Mass spectrometry. Experimental designs for pot culture and field experiments; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Computer use in soil research.

2. AGRICULTURAL BIOCHEMISTRY

Scope and importance of biochemistry and molecular biology in plants. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages, cell organelles function and their fractionation. Chemical bonding in biological systems, pH and buffers. Thermodynamics and bioenergetics- concept of entropy, and free energy changes in biological reactions, Redox reactions, Role of high energy phosphates. Biomembranes. Classification structure, chemistry, properties and function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins. Anabolism, catabolism and their regulation. Metabolism of carbohydrates – glycolytic pathway, HMP pathway, TCA cycle, glyoxylate pathway and gluconeogenesis. Biological oxidation- electron transfer and oxidative phosphorylation. Lipid metabolism, degradation and biosynthesis of fatty acids, ketogenesis and causes of ketosis. Biosynthesis of sterols and phospholipids. Amino acid metabolism – catabolism of amino acids, transamination and deamination, 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. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites, biotransformation and over expression. Major classes of enzymes, general properties, kinetics, active site and its mapping, activation energy and transition state. Mechanisms of enzyme action, inhibition and activation. Coenzymes and cofactors. Isoenzymes and immobilized enzymes. Regulation of enzyme activity, allosteric regulation. Multi substrate reactions, kinetic experiments to determine the mechanism of multi substrate reactions. Isolation, purification and measurement of enzyme activity. Enzyme units. Enzyme engineering. Role of enzymes in agriculture, industry, and medicine. Structure, mode of action and metabolic functions of

vitamins. Deficiency diseases associated with vitamins. General description of nature hormones and disorders associated with endocrine glands, viz. pituitary, thyroid, adrenal, pancreas and gonads. Peptide and steroid hormones. Phyto hormones – auxins, gibberellins, cytokinins, ethylene, abscisic acid and new plant bio-regulators like SA, Brassino. Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eukaryotes. Chloroplast and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization and mapping, functional genomics. Gene silencing. Methods for the development of transgenic organisms. Computer application in molecular biology, primer designing, sequence analysis and phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips. Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Electrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. Cell tissue and organ culture. Cryopreservation, PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression. Fundamentals of nutrition, concept of balanced diet. Nutritional quality of protein and its evaluation. Dietary fibre. Vitamins- biochemical functions and deficiency diseases. Fats and lipids-types of fatty acids and their significance in health. Biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables. Biochemistry of fruit ripening, biochemical aspects of post harvest technology, storage and preservation. Biochemical basis of quality improvement of food grains, vegetables and fruits. Antioxidants, nutraceuticals. Food toxins and anti-metabolites, food additives, storage proteins. Photosynthesis – photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Regulation of Rubisco. Chemiosmotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplast morphology, structure and biochemical anatomy. Cytosolic and organelle interactions. Nature and exchange of metabolites through translocators. Seed reserve biosynthesis. Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Signal transduction and phytohormones. Molecular mechanisms of plant growth, hormone action. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates. General organization of nuclear, mitochondrial and chloroplast genomes. Genomics and functional genomics. Tissue specific expression of genes. Molecular biology of various stresses – drought, salinity and temperature. Signal transduction and its molecular basis: molecular mechanism of plant hormone action. Structure, organization

and regulation of nuclear genes. Genes involved in photosynthesis and nitrogen fixation. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Molecular markers in plants and their uses. Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplast fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer –direct and vectormediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – insect-pest resistance (insect, viral, fungal and bacterial diseases). Abiotic stress tolerance, herbicide resistance, storage protein quality improvement, increasing shelf- life, oil quality. Biosafety and IPR issues.

3. AGRICULTURAL CHEMICALS

Surface chemistry, pH, Buffer solutions; Redox reactions, Chemical kinetics, Stereochemistry and chirality, diastereoisomerism, tautomerism, atropisomerism, asymmetric synthesis, nomenclature of organic molecules, displacement, elimination, addition, rearrangement, SN1 and SN2 reactions, reaction involving free radicals, and carbene intermediates, Organic reagents and catalysts in organic synthesis,. Beckmann, Claisen condensation, Hofmann-Löffler-Freytag reaction, Petrucci-Buchi reaction, Curtius, Michael, Kolbe, Arndt-Eistert and Wittig reaction. Reformatsky reaction., Barton reaction, Umpolung reaction, Norrish Type I & II reactions. Basic principles and application of chromatography; column, paper, thin layer, and ion exchange chromatography; gas liquid chromatography (GLC); high performance liquid chromatography (HPLC); UV, FT-IR; NMR and mass spectroscopy; GC-MS and LC-MS techniques and their applications. Extraction of natural products; Classification, structure, chemistry, properties and function of carbohydrates, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, and polymers. Chemistry of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and saponins; juvenile and moulting hormones; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products. Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; microbial macrolides (avermectins and milbemycins), agricultural antibiotics, semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators; Plant hormones, phytoalexins, essential oils and their pest control properties; advantages and limitations of natural pesticides; juvenile hormones, juvenile hormone mimics and anti-JH; chemosterilants, insect antifeedants, insect attractants and repellents; microbial pesticides; Application of plant biotechnology in crop protection, herbicide tolerant and insect resistant transgenic plants. History, scope and principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus, organo-carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's, phenols, quinines, carboxamides, azoles, methoxyacrylates), rodenticides, Insect growth regulators; Chitin synthesis inhibitors, insecticide synergists, fumigants. Mode of action of different groups of insecticides, fungicides and nematicides. Physical, chemical and toxicological properties of different groups of herbicides (phenoxyacids, carbamates, amides, triazines, phenyl ureas, dinitroanilines, bipyridiliums, sulfonyl ureas), Herbicide safeners, Plant growth regulators – auxins, gibberellins, cytokinins, ethylene, abscisic acid; Brassinolides; Mode of action of different groups of herbicides. Basic concepts of pesticide formulation - classification, solid and liquid formulations; preparation, properties, uses; controlled release formulations; Formulants - carriers/ diluents, surfactants, encapsulants, binders, anti-oxidants, stabilizers; Application - devices and quality of deposits; Types of spray appliances, seed treatment and dressing; nanotechnology in crop protection, Tools to develop and measure nanoparticles. Pesticide residues- concepts and toxicological significance; pesticide

dynamics in agro ecosystem, biotic and abiotic transformations affecting fate of pesticides. Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of ELISA and radiotracer techniques in pesticide residue analysis; new cleanup techniques, QUECHERS, ASE (Accelerated solvent extraction); Multi-residue methods; Bound and conjugated residues; Method validation - linearity, LOD and LOQ, microbial and photochemical degradation, adsorption/ desorption, leaching in soil. Production, consumption and trade statistics of pesticides and fertilizers; banned and restricted pesticides, registration and quality control of insecticides; Laws, Acts and Rules governing registration and regulations of agrochemical production and use; key provisions of the Insecticides Act (1968), Environmental Protection Act (1986). Pesticide Management Bill, EPA, Food Safety and Standards Act, WHO, FAO, CODEX and national/international guidelines; Quality Control, Sanitary / phyto-sanitary issues in relation to food safety, good laboratory practices, Accreditation certificate, Pesticide stewardship. Soil, plant and microbial biodiversity, Characteristics and classification of natural resources; Major soil groups of India their characteristics, management strategies for natural resources; integrated pest and pesticide management; Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc); production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems; benefits, disadvantages and environmental toxicity. Nitrification inhibitors to enhance nitrogen use efficiency, Hydrogels and their application in agriculture, soil conditioners and amendments, toxicity issues. Problems of pesticide hazards and environmental pollution; Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms; Effect of pesticide on soil health, persistent organic pollutants, and their effect on ecosystem. Adverse effect of industrial effluent on the soil and aquatic environment; disposal of obsolete and outdated pesticides; physical, chemical and microbial decontamination and detoxification of pesticides. Agrochemicals and homeland security, misuse of agrochemicals (pesticides and fertilizers), hazard mitigation plans or strategies, analytical and bioassay techniques to assess off-farm migration of agrochemicals into natural waters, ozone depletion causing agrochemicals. Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; Hest, chi-square (X²), F test., Probit analysis.

4. AGRICULTURAL ECONOMICS

Role of agriculture in economic development; growth and development, characteristics of developing and developed economies; theories of development; role of economic, technological, social, cultural, political and environmental factors; interdependence between agricultural and industrial development; growth models - Harrod-Domar, neo-classical, Von Neumann; development strategies in India; five-year plans and agriculture. Agricultural growth analysis - determinants of agricultural growth and their measurements; planning models, features of planning in capitalist, socialist, neo-socialist and mixed economies; types of planning - micro level, regional, sectoral, agro-eco regional development; role of non-government organisations (NGOs) and self help groups (SHGs) in agricultural development; characterizing agricultural growth, changes in cropping pattern, decomposition analysis and sources of output growth; analysis of instability; capital formation, crop livestock insurance, infrastructure; transfer of technology - constraints to technology adoption, yield gap analysis and research planning; agricultural information system. Agricultural policy analysis and reforms - energy, water, fertilizer, land, seed, labour, technology, rural infrastructure, marketing, pricing, trade etc. Concepts of food security, production oriented policies, food price policies, food subsidies, food

safety net and food quality. Measurement of poverty, poverty alleviation programmes. Characteristics and classification of natural resources; sustainability issues in natural resources; role of economics in natural resource accounting, planning, management and policy formulation; social welfare function; allocation of renewable and non-renewable resources (forests, water, land, etc.) under various market structures: management strategies for major natural resources; Government programmes for conservation and development of natural resources. Basic principles of farm management - marginal returns, opportunity cost, cost substitution, equimarginal returns, enterprises combination, time comparison and comparative advantage; cost concepts and analysis; farm efficiency measures; farm financial analysis; farm planning and budgeting; book keeping and accountancy; process of decision making under different knowledge situations; measurement and management of risk and uncertainty in agriculture (including livestock, horticulture, fisheries, forestry, etc.), diversification and insurance in agriculture and allied sectors. Forms and applications of production functions - linear, quadratic, square root, spillman, cubic, semi-log, Cobb-Douglas, constant elasticity of substitution (CES), variable elasticity of substitution (VES), etc; dualities between production, cost and profit functions; derivation of supply and factor demand functions from production and profit functions; optimization of resource allocation; product-product relationships; resource-enterprise organization; resource-use efficiency and returns to scale; frontier production function; total factor productivity; rainbow (green, white, yellow, blue, etc.) revolution. Importance of agricultural finance; rural credit structure-demand, supply, sources and forms; estimation of credit requirement; cost of credit/capital; credit appraisal- 3 Rs and 3 Cs of credit; reforms in agricultural credit policy; innovations in agricultural financing - microfinance, kisan credit cards; role of institutions in agri-finance - public and private sector banks; cooperatives, micro-finance institutions (MFIs), SHGs; international financial institutions; principles of agricultural financial management; successes and failures of co-operative sector in India; Role of co-operatives under emerging economic scenario; agricultural project analysis; Internal Rate of Return (IRR), Benefit Cost (B-C) ratio analysis. Marketing in a developing economy; structure, conduct and performance analysis; marketable and marketed surplus; marketing functions; processing, transportation, storage and warehousing; forward trading, futures market; and commodity, boards; channels in marketing, price spread and efficiency; problems in marketing agricultural produce; government interventions including regulated markets, procurement, buffer stock operations, co-operative marketing etc.; demand and supply models-formulation, estimation and projections; marketed surplus models: marketing of agricultural inputs; market integration; price stabilization measures and policies. The agribusiness system; management processes, planning, controlling, organizing, motivating and leading; decision making; managerial skills; level of managers; organizational context of decisions; decision making models; management by objectives; organizational culture; management of organizational conflicts; managing change; leadership styles; group dynamics; motivation. Human resource planning, job analysis and design; recruitment, selection, induction and placement; human resource training and development; management development; performance appraisal and job evaluation; wage and salary administration; promotion, transfer, separation, absenteeism and turnover, employee welfare and safety; morale; personnel supervision; styles; participative management; labour management relations; negotiation and negotiating skills; conflict management. Fundamentals of accounting and book-keeping; objectives and functions of financial management; analysis of financial statements- balance sheet, income statement, cash flow statement; capital structure theories; sources of long term finance and cost of capital; concepts of components of working capital, managing working capital - cash management, dividend decision; capital budgeting, appraisal criteria; agribusiness financing system in India-money and capital markets, national, regional and global financial institutions; rural insurance; risk management; micro-credit. Indian marketing environment; rural marketing; agricultural marketing system, wholesaling and retailing, consumer behaviour; the buying process; marketing mix; marketing strategy; planning

marketing mix; market segmentation; land targeting; marketing organization, marketing information system, market research, marketing extension; rural retailing; international marketing and finance. Operations management of an agro-industrial unit including operations system and processes; productivity of operations; work force productivity; facilities management; operations planning and control; material and supply chain management; quality management. Strategic management – meaning, concept and scope; framework for strategic management; industrial (external) and organizational (internal) environmental factors influencing strategy; scanning the external and internal environment; strategy formulation; SWOT analysis; strategy implementation; strategy and structure, strategic analysis, strategy and technology, strategy and leadership, total quality management, the customer resource, development of strategy, creating competitive advantage strategy, evaluation of strategy. Entrepreneurship and small business concepts; process of business opportunity identification; project feasibility study; detailed business plan preparation; managing small enterprises; planning for growth; sickness in small enterprises; government policies for promotion of small and tiny enterprises; rehabilitation of sick enterprises; entrepreneurship.

5. AGRICULTURAL EXTENSION

Concepts and scope of extension and communication particularly for primary and secondary agriculture. Historical and emerging perspectives of agricultural, veterinary and animal husbandry extension education in India and other countries. Community Development and Integrated Rural Development- concept, principles and objectives. Role of agricultural extension in different sectors of agriculture and rural development. Agricultural Extension in the context of enhancing productivity, Quality, Nutrition, post harvest technology, product processing, Profitability, Income and Employment. Concepts of yield gaps. FLD and OFT in relation to TOT programmes. Farming System Research and Extension (FSR&E) and participatory development approaches. Concept and modules of communication, credibility, fidelity, empathy and feedback in communication. Similarities and dissimilarities among extension education, adult education and continuing/distance education. Andragogy and theories of adult learning. Human behavioural dimensions and gender sensitivity in extension education programmes. Meaning and characteristics of attitude, factors affecting attitude change; Understanding of basic rural institutions, social structure, culture and norms. Social and technological change processes, group dynamics, concepts and theories of rural leadership. Group and mass communication, Interpersonal and Intrapersonal Communication Skills, Key communicators and their role in animal husbandry development. Acquiring communication skills for development of local leaders and key communicators for livestock development. Organizational communication. Rapport building with clientele. Problems and barriers in communication; distortion and noise in communication. Importance of feedback in veterinary extension, impact analysis of extension programmes. Concepts of teaching and learning processes—principles of learning as applied to agricultural extension. Individual, group and mass approaches in extension, audio-visual aids-classification, selection, use and production. Traditional media for communication in development programmes. Modularized communication- concept, approach, need, process of designing instruction for transfer of communication. Basics of agricultural journalism, types of publications – bulletins, folders, leaflets, booklets, newsletters, popular and scientific articles. Selection, planning and use of different extension teaching methods like demonstration, exhibition, farmers fairs, field days, tours, extension literature, etc. Preparation and presentation of different projected and non-projected audio-visual aids. Public speaking. Preparation of radio/video script. Principles of photography and its use in extension. Concept of ICT and its role in agriculture and rural development. ICT tools- print and electronic media, e-mail, Internet, use

of multimedia, use of mobile phony, video and teleconferencing, computer-assisted instructions, touch screens, micro-computers, web technologies and information kiosks. Networking system of information and challenges in the use of ICT. E-learning, information resources, sharing and networking. Types of net work – PAN, LAN, WAN, Internet, AGRINET, AKIS, Indian National Agricultural Research database. ICT programmes in livestock development, Problems and prospects of ICTs in livestock development, Digitisation, Simulation models, Utilization of Internet for promoting advanced veterinary and animal husbandry practices; communication with rural, semi-urban and urban livestock owners. Human resources and their importance in agricultural development. Concept of human resource management. Training and development of human resources. Identifying training needs and assessment of training impact. Training – principles, importance, methods and factors. Phases of training - pre training and post training. Developing training modules, training requirements, training methods. Lecture cum demonstration method, case method, group brain storming, syndicate method, business games, simulation exercises, in basket exercise, programmed instruction, experiential learning.

6. AGRICULTURAL METEOROLOGY & PHYSICS

Laws of radiation: Planck's law, Stephan-Boatman law, Wein's displacement law; Kirchoff's law, Beer's law and Lambert's, Cosine law, Solar constant, length of day;

Atmospheric and astronomical factors affecting depiction of solar radiation; Ozone hole; Direct and diffuse radiation; Heat transfer, convection, conduction and radiation; Concepts of latent and sensible heat; Radiant flux and flux density; Atmospheric motion balanced forces; Gas laws, pressure gradient, isobars, hydraulic equation and its application; Coriolis force, geotropic, gradient and cyclostrophic winds; Pressure systems; Cyclones and anticyclonic motions: trough, ridge and col; Thermal wind; Contour charts, Concepts of specific heat at constant volume and pressure; First and second laws of thermodynamics, vapor pressure, specific humidity, relative humidity, mixing ratio, absolute humidity and dew point temperature; Vapour pressure deficit; Psychometric equation, entropy, T-phi gram; Vertical stability of atmosphere, virtual temperature and potential temperature; Moist and dry adiabatic processes; Clouds their description and classification; Condensation process-artificial rain making; Bergeron-Findeison theory; Dew, frost, fog, mist, haze thunderstorm and hail; Air masses and fronts; Extra tropical cyclones; Land and sea breeze; Mountain and valley winds; Tropical cyclones and their structures; Weather variables and their measurements; Units for measurements of momentum, force work, power, surface tension, pressure, temperature; Thermal - conductivity and diffusivity, resistance, radiation light intensity and water vapour. Elements of weather and climate; Seasonal distribution of radiation, rainfall. temperature sunshine, wind pressure over India; Climatic classification - Koppen and Thornthwaite; Climatology principles of weather phenomena occurring in four main seasons of India; Mechanism of Indian monsoons; Climatic variability, recent trends, factor affecting rainfall distribution, cyclones and cyclonic tracks over the Indian region; North western disturbances and monsoon breaks; Drought climatology, rainfall and its variability, atmospheric and agricultural droughts intensity, duration, beginning and end of drought and wet spells; Moisture availability indices; Heat and cold waves; Contingents, maritime and monsoon climates, El-Niño, La Nino and their impact on Indian rainfall systems. Meaning and scope; Effect of thermal environment on growth and yield of crops; Cardinal temperatures; Thermoperiodism, photoperiodism; Vont Hoff's law, phenology of crops; Heat unit concept, thermal time and thermal use-efficiency and their applications; Length of growing period determination. contingency planning far different weather aberrations; Meteorological factors associated with incidence and development of crop pests and disease, potato blight, apple scab, groundnut red hairy caterpillar, locust etc.; Effect of climate on humans and animals, warm and cold season indices for comfort zones, role of weather in animal disease

and protection against weather hazards. Concept of micro, meso and macro meteorology; Micrometeorological processes near bare ground and crop surfaces; Shearing stress, molecular and eddy diffusion, forced and tree convection; Boundary layer, frictional velocity, roughness length and zero plane displacement; Micrometeorology of crops, rice and wheat; Day and night radiation, humidity, temperature, wind and CO₂ profiles in crop canopies; Richardson number, Reynolds analogy, exchange coefficients, fluxes of momentum, water vapors, CO₂ and heat; Inversion and its effect on smoke plume distribution; Windbreaks and shelterbelts, different methods on modification of field microclimate; Frost protection, spectral properties of vegetation; Light interception by crop canopies as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use-efficiency; Microclimate of field crops, forest and orchards etc. Hydrological cycle and concept of water balance, concepts of evaporation, evapotranspiration, potential and actual evapotranspiration, consumptive use, different approaches of ET determination empirical methods, energy balance and Bowen's ratio methods, water balance single and multilayered soil methods, aerodynamic, eddy correlation and combination approaches, field lysimetric approaches and canopy temperature based methods; Advantages and limitations of different methods; Water use and water use-efficiency, dry matter production and crop yield functions; Irrigation scheduling based on ET; Advective energy determination and its effect on water use by crops; Physiological variation in relation to crop growth and development. Concepts of mechanistic and deterministic models; General features of dynamical and statistical modeling techniques; Crop weather models and their use in crop yield assessments; Crop weather analysis models, empirical, statistical models, and crop growth simulation models for yield assessment; Use of SPA and CERES models, concepts for crop growth and yield; Advantages and limitations of modeling, climatic change, greenhouse effect, CO₂ increase, global warming and their impact on agriculture. Crop weather calendars: Short, medium and long range weather forecasting; Monsoon onset and rainfall forecasts; Weather forecasting and agro-advisories; Use of satellite cloud imageries in weather forecasting; Synoptic charts and synoptic approach to weather forecasting, use of medium, long range and vegetative indices based agro meteorology forecasts for monitoring crop prospects and crop yield forecasts; Meteorological satellites for weather forecasts; Forecast of Indian monsoon rainfall; Early warning systems for agriculture operation forecasts.

7. AGRICULTURAL STATISTICS

Descriptive statistics. Elements of probability theory, conditional probability, Bayes' theorem. Random variable discrete and continuous. Mathematical expectation. Moment generating and characteristic functions. Laws of large numbers. Central limit theorem. Discrete probability distributions binomial, Poisson, negative binomial and hypergeometric. Continuous probability distributions normal, rectangular, Cauchy, exponential, gamma and beta. Sampling distributions chi-square, t, and F. Bivariate normal distribution conditional and marginal. Point estimation unbiasedness, consistency, efficiency, sufficiency. Completeness, Minimum variance unbiased estimator. Cramer-Rao Inequality. Rao-Blackwell theorem and Lehman-Scheffe theorem. Methods of point estimation like Maximum likelihood, Moments, Minimum chi-square. Confidence interval estimation. Testing of hypotheses two types of errors, level of significance and power of a test. Neyman-Pearson Lemma. Uniformly most powerful tests and their construction. Unbiased test, Likelihood ratio test. Tests of significance based on Z, t, chi-square and F distributions.

Correlation, rank correlation, correlation ratio, intra-class correlation. Simple and multiple regression analysis, partial and multiple correlation. Examination of residuals. Model-

adequacy, Selecting best regression. Order statistics. Non-parametric tests run, sign, rank, Wilcoxon, Kruskal-Wallis, Mann-Whitney, Cochran and

Friedman's tests. Contingency tables. Log linear models. Sequential analysis sequential probability ratio test. Elements of stochastic processes. Multivariate normal distribution estimation of mean vector and dispersion matrix. Wishart distribution, Hotelling T₂, multivariate analysis of variance, principal component analysis, factor analysis, discriminant analysis, cluster analysis.

Statistical analysis of segregation, detection and estimation of linkage. Gene and genotypic frequencies. Random mating and equilibrium in large populations. Disequilibrium due to linkages for two pairs of genes and for sex linked genes. Selection, mutation and migration. Equilibrium between forces in large population.

Polymorphism. Fisher's fundamental theorem of natural selection. Polygenic systems for quantitative characters, Concepts of breeding value, dominance, average effect of gene and epistatic interactions

Genetic variance and its partitioning. Correlation between relatives. Regular system of inbreeding, effects of inbreeding. Genotype and environment interaction, stability parameters. Estimation of heritability, repeatability and genetic correlation. Path coefficient analysis. Heterosis, concepts of general and specific combining abilities. Diallel crosses and line \times tester analysis. Response due to selection. Prediction of response to individual, family and combined selections. Construction of selection index.

Linear models Random, fixed and mixed effects. Nested and crossed classifications. Gauss-Markoff theorem. Analysis of variance. Principles of design of experiments. Uniformity trials. Completely randomized design. Randomized complete block design. Latin square design. Factorial experiments 2^n and 3^n series and asymmetrical factorial experiments, confounding in 2^n and 3^n experiments, split and strip-plot designs, change over designs. Missing plot techniques. Analysis of covariance. Variance stabilizing transformations.

Balanced incomplete block designs and their analysis with and without recovery of inter block information. Partially balanced incomplete block designs with two associate classes, lattice designs. Youden square design. Multiple comparison procedures. Fractional replication of symmetrical factorials, confounding in asymmetrical factorial experiments. Response surface designs, second order rotatable designs. Combined analysis of groups of experiments. Sampling in field experiments. Experiments on cultivators' fields.

Sampling versus complete enumeration. Concept of probability sampling. Simple random sampling. Stratified sampling, allocation in stratified sampling, choice of strata, construction of strata boundaries and collapsing of strata. Use of auxiliary information in sample surveys, ratio and regression methods of estimation. Systematic sampling. Cluster and multi-stage sampling with equal probability.

Sampling with unequal probabilities with and without replacement, sampling schemes with inclusion probabilities proportional to size. Unbiased ratio type of estimators, Double sampling, sampling on successive occasions, inverse sampling. Non-sampling errors sources and classification. Non-response in surveys interpenetrating sub-samples, randomized response techniques, imputation methods. Design and organization of pilot and large scale surveys. National sample surveys. Agricultural statistics system in the country land use statistics, crop estimation surveys, livestock and fishery statistics.

Computer Organization and Architecture- number system, input/output unit, memory, arithmetic logic unit and control unit.

Computer algorithms. Programming in C-Building blocks, control structures, arrays, pointers, dynamic memory allocation, file management. Data Structures linked list, stack, queue, tree, graph, sorting and searching algorithms. Data Base Management System definition and features,

data models, relational database. Object oriented programming encapsulation, inheritance, polymorphism with C++/JAVA. Networking need, basic concepts, types of networks. Connecting computers local area networks, wide area networks. Value added network services E-mail, on-line services, Internet, etc. Hyper Text Markup Language (HTML), Building static and dynamic web pages. Numerical analysis interpolation, numerical integration, solution of ordinary differential equations, solution of linear and non-linear system of equations. Modeling and simulation random number generation and testing, discrete simulation models, simulation of stochastic events and processes, design of simulation experiments, analysis of data generated by simulation experiments, validation of simulation models. Linear Programming formulation and graphical solution, simplex method, duality, transportation and assignment problems.

8. AGRONOMY

Principles of crop ecology; Ecosystem concept and determinants of productivity of ecosystem; Physiological limits of crop yield and variability in relation to ecological optima; Crop adaptation; Climate shift and its ecological implication; Greenhouse effect; Agro-ecological and agro climatic regions of India; Geographical distribution of cereals, legumes, oilseeds, vegetables, fodders and forages, commercial crops, condiments and spices, medicinal and aromatic plants; Adverse climatic factors and crop productivity; Photosynthesis, respiration, net assimilation, solar energy conversion efficiency and relative water content, light intensity, water and CO₂ in relation to photosynthetic rates and efficiency; Physiological stress in crops; Remote sensing: Spectral indices and their application in agriculture, crop water stress indices and crop stress detection. Scope and principles of weed management; Weeds' classification, biology, ecology and allelopathy; Crop weed competition, weed threshold; Herbicides classification, formulations, mode of action, selectivity and resistance; Persistence of herbicides in soils and plants; Application methods and equipment; Biological weed control, bio-herbicides: Integrated weed management; Special weeds, parasitic and aquatic weeds and their management in cropped and non cropped lands; weed control schedules in field crops, vegetables and plantation crops; Role of GM crops in weed management. History of soil fertility and fertilizer use; Concept of essentiality of plant nutrients, their critical concentrations in plants, nutrient interactions, diagnostic techniques with special emphasis on emerging deficiencies of secondary and micro-nutrients; Soil fertility and productivity and their indicators; Fertilizer materials including liquid fertilizers, their composition, mineralization, availability and reaction products in soils; Water solubility of phosphate fertilizers; Slow release fertilizers, nitrification inhibitors and their use for crop production; Principles and methods of fertilizer application; Integrated nutrient management and bio-fertilizers; Agronomic and physiological efficiency and recovery of applied plant nutrients; Criteria for determining fertilizer schedules for cropping systems direct, residual and cumulative effects; Fertilizer related environmental problems including ground water pollution; Site-specific nutrient management; Contamination of heavy metals in peri-urban soils and their remediation. Concept of dryland farming; dryland farming vs rainfed farming; History, development, significance and constraints of dryland agriculture in India; Climatic classification and delineation of dryland tracts; Characterization of agro-climatic environments of drylands; Rainfall analysis and length of growing season; Types of drought, drought syndrome, effect on plant growth, drought resistance, drought avoidance, drought management; Crop Planning including contingency, crop diversification, varieties, cropping systems, conservation cropping and mid-season corrections for aberrant weather conditions; Techniques of moisture conservation in-situ to reduce evapotranspiration, runoff and to increase infiltration; Rain water harvesting and recycling concept, techniques and practices; Timelines and precision key factors for timely sowing, precision in seeding, weed control; Fertilizer placement, top dressing and

foliar application, aqua-fertigation; Concept and importance of watershed management in dryland areas. Problem soils and their distribution in India, acid, saline, waterlogged and mined - soils; Response of crop to acidity, salinity, sodicity, excess water and nutrient imbalances; Reclamation of problem soils, role of amendments and drainage; Crop production techniques in problem soils - crops, varieties, cropping system and agronomic practices; Effects of water table fluctuation on crop growth; Degraded lands and their rehabilitation. Crop production techniques for cereals, millets, legumes, oilseeds, fiber crops, sugarcane, tobacco, fodder and pasture crops including origin, history, distribution, adaptation, climate, soil, season, modern varieties, fertilizer requirements, intercultural operations, water requirement. weed control, quality components, industrial use, economics and post harvest technology. Frequency distribution, standard error and deviation, correlation and regression analyses, co-efficient of variation; Tests of significance-t, F and chi-square (X²); Data transformation and missing plot techniques; Design of experiments and their basic principles, completely randomized, randomized block, split plot, strip-plot, factorial and simple confounding designs; Efficiency of designs; Methods of statistical analysis for cropping systems including intercropping; Pooled analysis. Concept of sustainability; Sustainability parameters and indicators; Conservation agriculture; Alternate land use systems; Types, extent and causes of wasteland; Shifting cultivation; Agro forestry systems; Agricultural and agro-industrial residues and its recycling, safe disposal; Allelopathy and biomass production. Soil and water as vital resources for agricultural production; Occurrence of groundwater, groundwater aquifers, exploration of groundwater; Hydrological cycle; Soil-plant water relationship; Fate of rain water received at the soil surface, runoff and infiltration reciprocity, factors affecting infiltration, means to enhance infiltrability of soil, mechanical and biological means to reduce runoff and soil loss; Water harvesting for crop life saving irrigations; watershed management; Soil and water conservation; Contingent crop plans and other strategies for aberrant weather conditions; Cropping patterns, alternate land use and crop diversification in rainfed areas; Analysis of hydrologic data and their use. Soil water relations, water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water; Soil irrigability, classifications, factors affecting profile water storage; Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head; Movement of soil water saturated and unsaturated water flow; Field water budget, water gains and water losses from soil, deep percolation beyond root zone, capillary rise; Evapotranspiration (ET), scope for economizing water, measures for reducing direct evaporation from soil and crop canopies; Soil physical properties in relation to plant growth and development; Erodability of soils and their prevention. Plant water relations: Concept of plant water potential, cell water relations, plant water potential and its components; Significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD); Water movement through soil - plant atmosphere systems, uptake and transport of water by roots; Development of crop water deficit, crop adaptation to water deficit, morpho physiological effect of water deficit; Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements. management and breeding strategies to improve crop productivity under different patterns of drought situations of limited water supplies; Effect of excess water on plant growth and production; Types of droughts, drought indices. Management of irrigation water; History of irrigation in India; Major irrigation projects in India; Water resources development; Crop water requirements; Concepts of irrigation scheduling, Different approaches of irrigation scheduling; Soil water depletion plant indices and climatic parameters; Concept of critical stages of crop growth in relation to water supplies; Crop modeling, crop coefficients, water production functions; Methods of irrigation *viz.* surface methods, overhead methods, drip irrigation and air conditioning irrigation, merits and demerits of various methods, design and evaluation of irrigation methods; Measurement of irrigation water, application and distribution efficiencies; Management of water resources (rain, canal and

ground water) for agricultural production; Agronomic considerations in tile-design and operation of irrigation projects, characteristics of irrigation and family systems affecting irrigation management; Irrigation legislation; Water quality, conjunctive use of water, irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas; Socio-economic aspects of on-farm water management; Irrigation water distribution, Irrigation efficiencies; Design of irrigation canals, design of irrigation structures; Interaction between irrigation and fertilizers. Problem soils and their distribution in India; Salt-affected, acidic, water logged soils; Ground water resources, water quality criteria and use of brackish waters in agriculture; Excess salt and salt tolerant crops; Hydrological imbalances and their corrective measures; Concept of critical water table depths for crop growth; Contribution of shallow water table to crop water requirements; Management strategies for flood prone areas crop and crop calendar for flood affected areas; Drainage for improving water logged soils for crop production; Crop production and alternate use of problematic soils and poor quality water for agricultural and fish production; Amelioration of salt affected soils.

9. ANIMAL SCIENCE

Cattle and buffalo production and management: Introduction – Development of Dairy Industry in India and world – Present status and future prospects of livestock development in India. Important breeds of cattle and buffalo, traits of economic importance and their inter-relationships - Selection of high quality animals - Role of management in improving the reproduction efficiency in farm animals. - Housing and rearing systems. Breeding Management: System of breeding Economic traits. Methods of Breeding - Prenatal and postnatal care and management of cattle and buffalo - Care of neonate and young calves - Management strategies for reducing mortality in calves, age at first calving and calving interval in cattle and buffaloes. Management of labour, Milking management, Machine milking and hand milking, Different laws governing the livestock sectors to produce quality products on par with international standards - Technique of harvesting clean and hygienic livestock products, transportation of animals, health management. Wallowing in buffaloes- Management of draught animals and summer management. Feed and fodder resources used for feeding of cattle and buffaloes– Scientific technique of feeding, watering – Computation of practical and economical ration, supply of green fodder around the year and enrichment of poor quality roughages. Sheep and goat production and management: Introduction - Population structure and importance- Advantages and disadvantages of sheep farming under different systems of management – type of housing and equipments- Important sheep and goat breeds- Advantages and disadvantages of sheep and goat farming. Breeding Management: Breeding seasons - fitness of purchase for first breeding - methods of detection of heat - Natural Service and artificial insemination - Care of the pregnant Animals - Breeding stock - Use of teaser - Culling. Feeding Management: Feeding methods - Principles to be followed in feeding and watering- feeder space, waterer space, Designing feeders and waterers. - Range management - Stocking rate and pasture improvement and utilization; management under stall fed conditions, Transportation of sheep and goat. Disease Management: Role of management in the prevention and control of diseases. Special Management: Deworming - Dipping and spraying- shearing - Avoidance of goatry odour in milk, Topping. Wool: Importance of wool - Fiber structure- Fleece characters - Goat fibers - Characters of mohair and pashmina, fur and Angora - Marketing of goat fibers / wool.- Planning of sheep and goat farm of various sizes - Economics of sheep and goat farming. Pig production and management: Introduction - Population and importance - Economic contribution of pigs - Advantages and disadvantages of swine keeping - Systems of management - Problems in pig

farming. Breeds of pigs - Selection of breeding stock - Breeding seasons - Age and weight at first services - Methods for detection of heat – Natural service and artificial insemination - Care of pregnant sows, piglets and growers - Care of breeding boar. Housing, sanitation and hygiene, disease prevention measures - Housing and equipment –Wallowing - Sanitation and hygiene - Role of management in the prevention and the control of diseases. Feeding and management of new born, weaner and finishers, dry, pregnant and farrowing sows - Feeding principles to be followed - Methods of watering – Feeder space – Water space, etc - Marketing: Methods of marketing in swine production - Record keeping. Rabbit production and management: Introduction - Importance of rabbit for meat and fur production, Common breeds and strains. System of housing – Common diseases and their control measure. Management of specific pathogen free animals. Feeding of rabbits at different stages of growth and production. Breeding - Age at maturity, litter size - Weaning – Feeding of growers – Selection of replacement stock, transportation of rabbit, marketing of meat and fur. Shelter management: General principles in planning animal houses- farmstead and animal houses - Selection of site and planning; layouts for livestock farm of different sizes in different climatic zones in India - Farm structures - General principles of construction of enclosures, floor and road. Housing requirements of different classes of Livestock - Preparation of layouts, plans, arrangement of alleys- Fitting and facilities in the houses for horses, dairy cattle, calves, bulls, work cattle, dogs, pigs, sheep, goats, and poultry. Improvement of existing buildings; water supply; feed and fodder delivery systems - Economics of Livestock housing. Housing - Disease control measures and sanitation of all classes of livestock. Definition of climate -Classification of climatic regions - Climatic factors- Assessment of climate - Study of climatic factors in relation to animal production. Light, natural and artificial light-mechanism of light action-photo period and light responses – Applications - Importance of light in production of animals and birds. Introduction of breeds into different climatic regions - Agro meteorology and weather forecasting for Animal Husbandry activities - Micro climate modification in animal houses. Estimation of microclimatic conditions in Animal house - Measurement of Temperature, Relative humidity, Air Velocity and Mean temperature of the surrounding, measurement of intensity of light in animal houses – Construction of climographs and hythergraphs -Estimation of cooling power of atmosphere heat tolerance test in bovines. Commercial layer production: Layer Industry in India and the World – Systems of layer farming – Location – Lay out of the farm – Systems of housing – Types of roofs, roof materials, pillars, trusses for poultry houses – Design of different Poultry Houses for large & medium size layer farms – Cages & modified cages for egg type birds – Layer farm equipments –Automation in poultry houses and its maintenance – Management of layers in different systems of rearing. Deep litter & cage system of management – Medication and vaccination schedules & procedure for layers – Lighting programme for egg type birds - Water quality standards, watering of layer and water sanitation – Brooder, grower and layer management – All in All out and Multiple batch system of rearing layers. Management of layers during peak egg production and maintaining the persistency in production–Factors causing uneven growth and low egg production -Monitoring egg production curve. Culling of unproductive birds – Record keeping – Biosecurity & health management – Management during different seasons – Induced moulting.- HACCP application for safe egg, value added egg production – Production of eggs free from harmful microbes, Mycotoxins & drug residues- Integration in layer production. Commercial broiler production: Broiler Industry in India and the World – Systems of rearing broilers – Location, layout and design of Broiler houses – Broiler farm equipment. Brooding and rearing of broilers- All in all out and multiple batch systems – Litter materials and deep litter management – Lighting for broilers – Environmentally controlled broiler houses & their management – Water quality and Watering of broiler and water sanitation- Management during different seasons. Mash, crumble and pellet feeding of Broilers – weekly growth rate, feed conversion and

livability in broilers- sex separate feeding – Feeding broilers for optimum growth rate & feed efficiency- Broiler performance indices – Broiler farm records. Broiler farm routine, medication and vaccination schedule – Bio-security and health management and their control – Systems of Integration in broiler production and marketing –transport of broilers– Different ways of marketing of broilers- Regulations and specifications for production of export quality broilers – Organic broiler meat production. Management of poultry other than chicken: Breeds and varieties of Turkey, Duck, Goose, Pigeon, Guinea fowl, Budgerigar, Japanese quail, Emu and Ostrich – Incubation periods & incubation procedure for different species – Housing, cage & equipments for different species – Duck, Turkey, Japanese Quail, Guinea fowl, Emu, Ostrich production and rearing under different systems. Management and rearing of Turkey, duck, goose, Guinea fowl, Japanese quail, pigeon, emu and ostrich- Feeding standards and feeding, watering and rearing systems and procedure for different species of poultry- Breeding policies of egg and meat production in different species – Preparation of Project reports for different species for commercial exploitation. Common diseases affecting poultry other than chicken and their control – Regulations for import and export of different species of poultry – prevention of exotic diseases through import of poultry products and live birds. Farm animal behavior: Introduction to Animal behaviour - Importance of animal behaviour studies - Patterns of behaviour - Daily and seasonal cycles of behaviour – Physiological basis of behaviour. Environmental modification of behaviour - Developmental changes in behaviour - Genetic differences in behaviour - Behavioural disorders. Group formation - Social relationship, process of socialisation locality and behaviour - Practical application - Behavioural character for managerial practices - Favourable and unfavourable behaviour for domestication - Behavioural adaptations under domestication. Physical environment and behaviour - Common vices and their remedial measures - Analysis of behaviour in relation to location - Analysis of behaviour in relation to climatic environment - Analysis of social behaviour. Principles of feed and fodder processing and preservation techniques, their merits and demerits. Procurement, planning and purchase procedures; traditional and modern farm level storage structures. Feed storage and godown management, estimation of storage capacity and stack plan. Evaluation of processed and preserved feeds and forages. Role of moisture, temperature and relative humidity during storage of feedstuffs and their effect on biotic factors. Handling and storage of liquid feed Ingredients. Physical and chemical changes in feeds during storage; storage losses; insect pests and rodents in feed stores and their control; Role of fungi, tolerance limits and measures to check them in stored products. Factors affecting the quality of feed and feedstuffs on preservation. Microbiological evaluation of processed and preserved feeds, Effect of preservation on nutritional value of feed. Properties and mode of action of pesticides and fumigants; principles of good sanitation and hygiene of godowns. Proximate composition, Limitations of various systems of analysis, Partitioning of forage fibre by Van Soest method, Quality control of fed ingredients, Specifications of feed ingredients and finished feeds, BIS standard., Pesticide and insecticide residues in feeds. Animal husbandry development programmes: Concept of development, social and economic development; Historical overview on Rural Development in India. Ongoing Animal Husbandry Development Programmes - NPCBB, PM assistance livestock development programme, rural development programmes with special reference to livestock- SGSY, EGS. Transfer of Technology (TOT) programmes of ICAR– National Demonstration, Krishi Vigyan Kendra, Trainers' Training

Centres, Lab to Land Programme, Operational Research Project, National Agricultural Research Project, Agricultural Technology Management Agency, National Agricultural Innovative Project. Understanding the functioning of livestock development institutions - DRDA, NABARD, Insurance Companies, NGOs. Integrated livestock farming system: Scope and

limitation of integrated farming systems - Sustainability of integrated Livestock Farming Systems and their economic importance. Integration of fish, arable farming and different livestock enterprises vis-à-vis *gobar* gas plant, FYM, solar and wind energy utilization, cattle, buffalo sheep, goat, pig, poultry, rabbit, silk worm, bee keeping etc. New approach for changing farming systems in present energy crises. Project formulation and evaluation of various livestock enterprises.

10. AGRICULTURAL ENTOMOLOGY

History and development of Entomology, Evolution of insects, position of insects in the animal world, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families. Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders. Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function and physiology of Digestive, Circulatory, Respiratory, Reproductive, Nervous and Excretory systems, Sense Organs; structure and types. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets. Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, population dynamics, distribution and dispersal. Principle of biogeography and insects biodiversity. Biotic potential and environmental resistance. Ecosystems, agroecosystems analysis, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasite interactions, ecological niche. Life table studies, population models. Food chain and food web. Arthropod population monitoring, pest forecasting. Diapause and causes of pest out breaks. Importance and scope of biological control, history of biological control: Biocontrol agents-parasites, predators and insect pathogens. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests. History, scope and principles of chemical control. Insecticides and their classification. Formulations of insecticides. Susceptibility of insects to the entry of insecticides. Physical, chemical and toxicological properties of different groups of insecticides: chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, chlordimeform, chitin synthesis inhibitors, avermectins, nitroguandines, phenylpyrrozzoles, botanicals (natural pyrethroids, rotenone, neem products, nicotine, pongamia spp. etc). Combination insecticides. Problems of pesticide hazards and environmental pollution. Safe use of pesticides, precautions and first aid treatments. Insecticides Act 1968, registration and quality control of insecticides. Evaluation of toxicity, methods of toxicity testing, determination of LD 50, LT 50, RL 50 etc. Pesticides residues in the environment and their dynamics of movements, methods of residue. Pharmacology of insect poisons. Mode of action of different groups of insecticides; neuroactive (axonal and synaptic)

poisons, respiratory poisons, chitin synthesis inhibitors. Metabolism of insecticides; activative and degradative metabolism, detoxification enzymes and their role in metabolism. Selectivity of insecticidal actions; insecticide resistance; mechanism, genetics and management of insecticide resistance. Chemical ecology: mechano and chemo receptors. Host plant selection by phytophagous insects. Secondary plant substances and their defenses against phytophagous insect. Basis of resistance (Antixenosis, Antibiosis, Tolerance). Biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Breeding for insect resistant plant varieties. Resistance development and evaluation techniques. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management. Behavioral control: pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Potentialities of IPM. History, concept and principles of IPM. Components of IPM: Host plant resistance, agronomic manipulations, mechanical and physical methods, chemical methods, biocontrol agents utilization, genetic and behavioral control strategy etc. IPM strategies for field and horticultural crops. IPM case histories. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. System approach, Agro ecosystem and cropping system vs. IPM. Constraints and Strategies of IPM implementation. Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Power operated sprayers and dusters. Types of nozzles and their uses. Maintenance of appliances. Aerial application of pesticides, principles of aerial application, factors affecting the effectiveness of aerial application. Equipments for aerial applications. Advantages and disadvantages of aerial application. Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy caterpillars, cut worms and white grubs. Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits and plantation crops, spices, condiments and ornamentals. Fundamentals of storage of grains and grain products. Storage losses, sources of infestation/infection, factors influencing losses, insect and non-insect pests, their nature of damage and control. Microflora in storage environment and their control. Storage structures, bulk storage and bag storage, their relative efficacy and demerits. Grain drying methods and aeration. Non-insect pests (rodents, birds, mites) of stored products and their control. Integrated management of storage pests. Common arthropod vectors *viz.*, aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psyllids, beetles, weevils, flies, bees and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission : Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases. Honey bees and their economic importance. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal management. Bee enemies including diseases and their control. Silkworm species, their systematic position and salient features. Rearing techniques of mulberry-muga-eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltinism and niultism, seed production and its economics. Enemies and diseases of silkworms and their management. Sericulture organization in India. Lac insect, its biology, habit and habitats. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control. Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects

and insect products in medicines. Usefulness of insects in scientific investigations, insects as food. Frequency distribution, mean, mode and median. Standard, normal, binomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi-square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, completely randomized block design, Latin square design, Split-plot designs. Probit analysis. Use of soft ware packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

11. GENETICS & PLANT BREEDING

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA – structure, function, replication and repair. Genetic code. Gene- enzyme relationship. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding. Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, minor millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soybean, pea, lentil, horse gram, lab-lab, rice bean, winged bean, lathyrus, Lima bean; oilseeds (groundnuts, sesamum, castor, rapeseed mustard, sunflower, Niger, linseed); fibers and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and clonally propagated crops. Component, recombinational and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding. Chromosome structure, function and replication. 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-and post- fertilization barriers in wide hybridization. Genome organization and cytogenetics of important crop species- wheat, maize, rice, Brassica, cotton, Vigna, potato and sugarcane. Principles and procedures of genome analysis. Cytogenetic techniques for gene location and gene transfer, Construction and use of molecular marker based chromosome maps. Comparative mapping and genome analysis. Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection and correlated response. Hardy Weinberg law. Linkage disequilibrium. Genetic load. Polymorphism. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combining ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability of performance. Heterosis and its basis. Mating system and mating design- diallel, line X tester, NC-1, NC-II and NC-III designs, approaches to estimate and exploit component of self and cross pollinated crops. Genotype X environment interaction and stability analysis. Somatic hybridization, micropropagation, somaclonal variation *in vitro* mutagenesis. Artificial synthesis of gene. Genetic and molecular markers, generations of molecular markers and their application in genetic analyses and breeding. Molecular markers in

genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping and marker aided selection. Genome projects and utilization of sequence formation. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nuclei acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies.

Genetic transformation and transgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement. Genetic basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits. Role of molecular markers in stress resistance breeding: MAS, MARS and MABB. Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resources. 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. System of variety release and notification. Types of seeds and seed chain. Seed production and certification. Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probability distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Design of experiments- basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.

12. PLANT PATHOLOGY

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments 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. 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. 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. Classification of fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition. Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in relation 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: *avr*, *her*, *vie* and *pat* genes. 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. 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. Transmission of viruses: virus - vector relationships. Nomenclature and classification of viruses. 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. Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourable soil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary air pollutants and acid rain. Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices and ornamental crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management. Post harvest diseases in transit and storage; aflatoxins and their integrated management. Crop diseases of cereals, pulses, oilseeds, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management. General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hypothesis; parasite mediated frequency - dependent selection concept of QTL mapping; breeding for disease resistance. Production of disease free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassay 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 plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria.

13.PLANT PHYSIOLOGY

Cell organelles and their physiological functions Structure and physiological functions of cell wall, cell inclusions. Cell membrane structure and functions. Water and its role in plants, properties and functions of water in the cell, water relations, water potential of plant cells. Mechanism of water uptake by roots transport in roots, movement of water in plants, water loss from plants, energy balance, solar energy, input energy dissipation at crop canopy level. Evapotranspiration, plant factors influencing transpiration rate. Stomata, structure function - Mechanism of stomatal movement, antitranspirants. Physiology of water high temperature and salinity stress in plants. Influence of water stresses at cell, organ, plant and canopy levels. Indices for assessment of drought resistance. Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bioproductivity. Photochemical process-Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, CO₂ fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis

of sucrose, starch, oligo and polysaccharides. Translocations of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism. Inorganic nitrogen species (N_2 , NO_3 , NH_3) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism- storage, protective and structural lipids. Secondary metabolites and their significance in plant defence mechanism. Growth and differentiation, hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cytokinins, ABA, ethylene etc.), biosynthesis of growth hormones and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photomorphogenesis, photo-receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation. Role of crop physiology in agriculture, crop growth and productivity, crop growth models describing yield (Duncan/Passioura), phenology-crop productivity, growth factors related to biomass - concept of growth rates- canopy photosynthesis (leaf area and net assimilation rates as determining factors). Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink, factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity. Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought 21 characteristic features, water potential in the soil-plant-air continuum. Development of water deficits, energy balance concept, transpiration and its regulation – stomatal functions/VPD. Physiological process affected by drought. Drought resistance mechanisms: Escape, dehydration postponement (Drought avoidance), Dehydration tolerance, and characteristics of resurrection plants. Osmotic adjustment Osmoprotectants, stress proteins. Water use efficiency as a drought resistance trait. Molecular responses to water deficit stress perception, expression of regulatory and function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as negative signal. Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSPs chilling stress; effects on physiological processes. Crucial role of membrane lipids. Salinity: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatin (heavy, metal binding proteins). Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteroids, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction Hormone mutants. Hormonal regulation of gene expressions at various developmental stages of plant-flowering, seed maturity, seed dormancy. Action of hormones on cellular functions: Auxins- cell elongation, retardation of abscission of plant parts, gibberellins – stem elongation, germination of dormant seeds, cytokinins-cell division, retardation of senescence. Abscisic acid- stomatal closure and induction of drought resistance, ethylene- fruit ripening, acceleration of senescence of leaves. Interaction of hormones in regulation of plant growth and development processes. Synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Growth and differentiation, hormonal concept of growth and differentiations. Rooting of cuttings- flowering- physiological and molecular aspects of control of reproductive growth. Apical dominance, senescence and abscission. Fruit growth and development, physiological and

molecular aspects of ripening processes and improving post harvest life of fruits. Induction and breaking dormancy in seeds and buds. Synthetic growth regulators. Practical utility in agriculture and horticulture. Herbicides, classification and their mode of action. Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of bio-membranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplast) to sieve across the root cortical cells-factors contributing to xylem loading. Long distance transport in xylem and phloem, xylem unloading in leaf cells. Uptake and release of mineral nutrients by foliage. Rhizosphere and root biology, root growth, influence of micro-organism in nutrient acquisition, release and uptake by plant roots. Yield and mineral nutrition-concept of nutrient use efficiency, Mineral nutrition under adverse soil situations-drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc. Climate- Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable ^{18}O discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warming. CO_2 as an important greenhouse gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric CO_2 level. Effect of elevated CO_2 on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCM models, effects on climate and biota. High temperature and CO_2 interaction on plant growth and productivity, ionising radiation UV-B chlorofluoro carbon (CFC)- their impact on ozone layer- ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution, SO_2 , NO , methane, ozone, peroxy acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent-their effect, on aquatic ecosystem, plant growth and development. Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Hydration of seeds. Physiological processes. Seed respiration, mitochondrial activity Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored reserves. Role of embryonic axes. Gibberellin and α -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy. Evolutionary history of flowering plants (angiosperms). Semelparous and iteroparous reproduction, monocarpic and perennial life etc. Flowering phenomenon, effect of plant age, juvenility- transition to flowering. Flowering nature and classification of plants. Photoperiodic responses and the mechanisms in short and long day plants. Theories related to flowering. Endogenous substances and flowering. Gene expression in flowering. Control of flowering. Thermoperiodism - photo and thermo-period interactions. Vernalization-mechanism. Photomorphogenesis, photoreceptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalization. Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology. Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (pollen-stigma interactions), seed and fruit development, seed and fruit abortion and means to overcome it. Molecular biology of seed development, physiological basis of cytoplasmic male sterility and fertility restoration. Physiology of heterosis. Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots, patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth

measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration rate and water use efficiency. Sexual and asexual propagation. Rootstock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops: mango, banana, grapes, citrus, papaya and pineapple etc. Physiological aspects of plantation crops: tea, coffee, cardamom, coconut, and blackpepper. Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds. Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest life of cut flowers. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life. Edible vaccine. Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and diffusive growing cells. Control of cell division and differentiation, phyto-chromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry of differentiation, in organ cell, tissue and cultures, micropropagation strategies, application of tissue culture in agriculture, horticulture, forestry and industry: plant transformation; transformation vectors, concept of selectable and scorable markers. *Agrobacterium* mediated transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis. PCR, Southern analysis evaluation of transgenic plants.

14. SEED SCIENCE & TECHNOLOGY

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and longevity in orthodox and recalcitrant seed. Chemical composition of seed. Seed dormancy - types, causes and mechanisms of induction and release, factors affecting, methods to overcome dormancy and its significance in agriculture. Seed germination - requirements, imbibition pattern, physiological and biochemical changes, and role of hormones. Introduction to crop breeding methods. Variety testing, release and notification. Genetic purity concept and factors responsible for deterioration of varieties. Maintenance breeding. General system of seed multiplication. Seed production agencies. Identification of seed production areas and factors affecting it. Compact area approach in seed production. Seed production planning, equipment, input and manpower requirement. Factors affecting pollination and seed set viz., temperature, humidity, wind velocity, insect pollinators, and supplementary pollination. Male sterility, self-incompatibility and their role in hybrid seed production. Principles and methods of seed production of varieties and hybrids of cereals like wheat, paddy, sorghum, pearl millet and maize; pulses like chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds like groundnut, brassica, sesame, sunflower and castor; fibre crops like cotton and jute; vegetables crops like tomato, brinjal, okra, chilli, important cole and cucurbitaceous crops; important forage legumes and grasses and seed crop management, time of harvesting and threshing/extraction methods. Seed production technology of plantation crops like coffee, tea, rubber, cocoa, cardamom and pepper. Disease free clonal propagation of crops like potato, sugarcane sweet potato, tapioca, colocasia, betel vine, fruit crops like mango, citrus, banana, guava, sapota, pineapple, grape, apple, pear, plum, peach, apricot and seed production and clonal propagation of annual and perennial flowers like

rose, gladiolus, chrysanthemum, marigold, dahlia, flox and petunia. Clonal standards and degenerations. Micro propagation. Principles of seed processing. Seed drying principles and methods. Precleaning, grading, treatment, pelleting and packaging. Seed invigoration and enhancement treatment and their applications. Seed processing machines like cleaner cum grader, specific gravity separator, indented cylinder, seed treater, weighing and bagging machines, their operation and maintenance. Seed quality maintenance during processing. Seed legislation - Seeds Act 1966, Seed Rules 1969 and New Seed Bill 2004, Seed Law Enforcement. Seed certification – history, concept, organization, phases and minimum certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre- and post quality testing or genetic purity. Seed Certification Schemes, concepts and procedures. Seed Testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance tests and equipment. Seed testing procedures for principal agri horticultural crops. Quick viability tests. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques namely electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade. Requirements and types of seed storage. Factors affecting seed storage and role of moisture, temperature, RH and moisture equilibrium. Viability nomographs. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Seed drying and Packaging needs. Storage structures. Methods of stacking and their impact. Short and medium term storage. Controlled storage. Germplasm storage. Cryo preservation. Design features of short, medium and long-term seed storage buildings. Operation and management of seed stores. Significance of seed health. Mode and mechanism of transmission of microorganisms - fungi, bacteria and viruses. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection of seed borne diseases. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. ET value, nature and extent of damage, natural enemies and management. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants. Trends in National and International seed industry development. International Seed Trade Federation (ISF) and Indian seed associations. Economics of seed production. Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Buyer behavior and role of Government, semi Government, co-operative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export. Plant Variety Protection (PVP) and its significance. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant breeders Rights and Seed Industry Development. Impact of PVP on seed supply system. DUS testing principles and application. Biodiversity Act. Criteria for protection of Essentially Derived Varieties (EDVs) and Genetically modified (GM) varieties.

15.SOIL & WATER CONSERVATION

History of soil erosion, definition, classification. Nature and extent soil erosion in India. Mechanics of soil erosion by water and glaciers. Factors and processes of soil erosion; its impact on environment and biosphere. Universal soil loss equation – defining all parameters and its use. Rainfall erosivity and soil erodibility. Mechanics of wind erosion – factors, process, wind erosion equation. Management of soil and nutrient losses. Shifting cultivation – principles, extent

and impact. Methods of soil erosion control – vegetative measures like crop rotation, afforestation, agrostological technique, etc. and mechanical measures like contour bunding, trenching, gully plugging, strip cropping, terracing, etc. Conservation farming system. Reclamation of ravine lands. Sand dune stabilization. Grazing and its impact on soil erosion. Forest fire and soil erosion. Control measures of grazing and forest fire.

Concept and definition of watershed, classification of watershed, shape and nature, importance of watershed management and its role in conservation of natural resources – soil, water and vegetation. Concept of water harvesting and runoff recycling, preparation of watershed management plan, selection of pond size and design of a pond, sedimentation problem in watershed, seepage control, watershed management for runoff and sediment control – economical aspects of watershed management.

Soil as a physical system, soil physical environment. Type of physical constraints. Physical constraints in relation to yield potential. Soil texture, soil structure, poorly aerated soil, compact soil. Soil water and its availability. Soil crust and clod formation problems and their prevention. Management of paddy soil, water permeability of paddy land. Soil conditioners and modifiers of soil structure. Soil moisture stress and plant growth. Soil moisture characteristics, Seedling emergence and root growth in relation to soil moisture stress. Soil moisture movement – concept of moisture potential. Techniques of soil moisture measurements. Soil temperature regimes. Root growth characteristics and moisture extraction pattern. Soil consistency, root-shoot ratio, mechanical impedance and aeration status.

Concept conservation farming and irrigation, role of vegetation, conservation tillage and mulch in various land climate conditions. Biological measures in dryland, rainfed, arid, semi-arid, and humid lands. Water use efficiency soil fertility, selection of draught tolerant plants, role of grasses, legumes in conservation, pasture and range-land management and its improvement. Management of waterways, canal bank, bench terrace through biological means.

Land degradation- type, factors, distribution, processes and impacts on soil productivity. Formation, nature and properties of problem soil. Land restoration and conservation techniques of reclamation of chemically degraded and problem soils. Acid soils – nature distribution, formation and properties, effect of acidic, halomorphic and hydromorphic conditions on plant growth and nutrient availability. Acid sulphate soils – occurrence, distribution, characteristics and effects on plant growth and nutrient availability and its reclamation techniques.

Definition and objectives, land use survey and classification, land capability survey – land capability class, sub-class and units. Irrigability survey, soil and land irrigability classes. Sub-class and units. Land suitability classification, sediment yield index. Soil survey- purpose, objectives and types. Taxonomic and mapping units for different types of survey – cartography. Soil classification based on depth, permeability, slopes and erosion. Land classification for gullies and ravine lands. Ratings of land capability classification.

Scope and development of hydrology, hydrologic cycle. Analysis of frequency, intensity, duration and probability of rainfall. Average precipitation, arithmetic mean, isohyetal, theissen polygon etc. Runoff – definition, runoff cycle, runoff rate, volume, methods of estimation of rate and volume, rainfall-runoff relationships. Ground water hydrology- occurrence, distribution and retention; hydrograph analysis – S-hydrograph. Infiltration – definition, factors affecting infiltration, cumulative infiltration, infiltration capacity. Estimation of infiltration – Kostiakov's equation, Phillip's equation. Measurement of infiltration. Hydraulic conductivity and infiltration

characteristics in soil, soil moisture characteristics, soil moisture constants. Soil moisture diffusion. Open channel hydrology, Manning's Co-efficient, wetted perimeter etc. Flow of water – V-notch, orifice, Parshall flume etc. Water stage recording. Concepts of open and close aquifers.

State of water in soil and its classification- gravimetric, capillary and hygroscopic moisture. Retention and drying characteristics of soil moisture. Energy concepts of soil water. Thermodynamic concept of soil water potential, significance and evaluation of total and its component potentials. Soil water retention and movement, field capacity, wilting point, water holding capacity and available water. Soil water storage and its depletion. Mechanism of soil moisture absorption by plants. Evapotranspiration and potential evapotranspiration. Soil moisture determination, soil moisture stress and plant growth. Estimation of water requirement by empirical formulae – Thornthwaite equation, Penman's equation, Blaney-Criddle equations. Critical analysis of the equations. Irrigation water quality in relation to soil and plant water. Measurement of soil water – lysimeter tensiometer, moisture meter, pressure plate etc.

Agroforestry- History, objectives, importance, potential. Agroecological zones, Multipurpose trees in agroforestry. Soil and water management in relation to agroforestry systems. Irrigation methods under agroforestry system, Optimization of water use in agroforestry systems and dry land farming. Role of trees in soil productivity and conservation. Tree root patterns. Soil fertility. Recycling of nutrients including organic matter decomposition, nutrients budgeting, physical conditions and soil productivity under different agroforestry systems.

Monsoon– types and behavior in India, rainfall – characteristics and distribution, onset and withdrawal of effective rains, dry spells and wet spells, critical dry spells, water loss from the soil, measurement and factors, hydrological cycle, Importance and issues relating water status. Rainwater harvesting- methods, classes, benefits, approach, water saving technologies, rainwater harvesting and draught mitigation, crop productivity and water security.

Types of micro-irrigation systems – sprinkler, drip, sub-surface. Design criteria and suitability of different micro-irrigations. Operation and maintenance of MIs. Feasibility and applicability of micro-irrigation systems under diverse soil – water - crop continuum. Dynamics of water and nutrient interaction in soils – water and nutrient use efficiency and savings. Economics of micro-irrigation systems in crop production.

Irrigation and drainage relations, sources of excess water and salts in soil. Development of drainage problems in different crops and soils, agricultural drainage – waterlogging, surface drainage and subsurface drainage, impact of waterlogging and drainage, drainage requirement of crops, drainage coefficient. Biodrainage - drainage alternatives.

Soil as a natural body, soil evolution, soil morphology and methods of its study. Soil development, soil formation – factors and process, pedons and polypedons, soil taxonomy – epipedons, diagnostic subsurface horizons, soil moisture and temperature regimes, USDA classification systems : order, sub-order, great group, sub-group, family, series, types, phase, benchmark soils.

Concept of soil moisture conservation, use and methods, rainfall and temperature distribution in India and rainfed farming areas. Soil water relation in rainfed farming – infiltration and available moisture storage. Soil moisture conservation measures – tillage, mulches – their different kinds, effectiveness and economics, draught resistance in crop, mechanism for draught situation, shoot and root growth characteristics. Water harvesting and life

saving irrigation. Moisture use efficiency and economics of conservation technique in low rainfall areas.

Basic concept of remote sensing, satellite remote sensing, satellite orbits, stages of remote sensing, band used in remote sensing, major components of remote sensing technology, various platforms and sensors, active and passive remote sensing. Characteristics of electromagnetic radiation and its interaction with matter; sensors in visible, infrared and microwave regions. Characteristics of Different satellites like IRS, INSAT, LANDSAT etc. Microwave remote sensing. Introduction to GIS and GPS. Software and hardware requirements in GIS. Application of remote sensing data in agriculture with special emphasis on soil and water conservation.

16. AGRICULTURAL BIOTECHNOLOGY

Structure and organization of prokaryotic and eukaryotic cells; organization and expression of prokaryotic and eukaryotic genome; concept of gene; quantitative trait loci, mutation; genetic recombination; transformation; transduction; conjugation; structure, function and regulation of genes in pro- and eukaryotes; replication, transcription and translation in Pro- and eukaryotes; molecular biology of different stresses; Molecular biology techniques, recombinant DNA, restriction enzymes, vectors, plasmids, cosmids and bacteriophages, expression vectors, cloning strategies, construction and screening of genomic and cDNA libraries, nucleic acid hybridization and DNA sequencing; genetic transformation of eukaryotes; Potential application of genetic engineering in crop improvement; Different types of plant tissue culture techniques and their role in crop improvement; IPR, biosafety and ethical issues related to GM crops, microbes in agriculture and industry; structure and function of proteins, nucleic acids; nucleic acid and protein biosynthesis; molecular markers and their role in crop improvement. QTL mapping, association mapping, marker assisted selection; Bioinformatics and role in agriculture, genomics, genome sequencing and genome analysis, comparative genomics and genome annotation, transcriptomics and proteomics, phylogenetic analysis.

FACULTY OF HORTICULTURE: (Course outline)

1. VEGETABLE SCIENCE

Importance, area, production and productivity, nutritional value and importance of vegetable and tuber crop; origin, distribution: classification of vegetables, types of vegetable growing, regions of cultivation and export and import of these commodities.

Definition of growth and development, dormancy and rest period, physiology of flowering, chemical induction of flowering, sex expression and alteration, fruit set and development, fruit drop, parthenocarpy, seedlessness; role of auxins, gibberellins, cytokinins, ethylene and other growth regulators including retardants in vegetable and tuber crop production.

Use of poly houses in vegetable production; drip and sprinkler irrigation, fertigation, shading; off-season production of high value vegetable crops; weed, insect nematode and disease control including IPM and organic farming

Soil and climate; seed rate, important varieties, nutritional requirements, deficiency disorders and corrective measures, irrigation spacing of important vegetables like, cole crops, cucurbits, bulb, root and tuber crops, solanaceous vegetables, leguminous vegetables, leafy vegetables, okra, etc.

Seed morphology, development, environmental factors responsible for belting and flowering, pollination systems, isolation, roguing and certification; seed production, storage and viability in important crops like tomato, chilli, brinjal, okra, onion, cucurbits, cole crops, and seed spices like fenugreek, coriander, cumin, fennel, etc; hybrid seed production.

Nursery establishment, preparation of soil mixtures, soil sterilization, containers, watering and plant protection practices; Use of vegetative propagation for vegetable and tuber crops.

Principles, problems and prospects of improvement of vegetable and tuber crops; introduction, selection including clonal selection and hybridization, mutation breeding, polyploidy and heterosis breeding for specific purposes like productivity, resistance to biotic and abiotic stresses and processing; recent advances in breeding including biotechnological approaches. Breeding objectives and advances made in important vegetables crops.

2. PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

Growth and development of spices and plantation crops; nursery management of spices and plantation crops; growth substances for production of spices and plantation crops; Nursery establishment, preparation of soil mixtures, soil sterilization, containers, watering and plant protection practices; use of vegetative propagation, selection of shoots in pepper and nutmeg, selection of rhizomes in cardamom, turmeric and ginger.

Modern production technology of plantation crops covering soils and climate; propagation, varieties; planting and planting density; training and pruning; nutrition and irrigation; weed, disease and pest control including IPM of important plantation crops like, coconut, arecanut, oilpalm, cashew, cocoa, tea, coffee, rubber, bête vine.

Soil and climatic seed rate, important varieties, spacing, irrigation, nutritional requirement, deficiency disorders and corrective measures; pest and disease including IPM and organic farming of spice crops like, black pepper, chilli, ginger, turmeric, cardamom, coriander, cumin, black cumin, fennel, fenugreek, curry leaf, clove, nutmeg, cinnamon.

Principles, problems and prospects of breeding of plantation crops; floral biology; methods of improvement e.g. introduction, clonal selection, hybridization, mutation breeding, polyploidy and heterosis breeding; breeding objectives, problems and advances made in plantation crops e.g. coconut, arecanut, oilpalm cashew, tea, coffee, etc.

Principles problems and prospects of spice crops improvement; floral biology; introduction, selection including clonal selection and hybridization; mutation breeding, polyploidy and heterosis breeding for specific purposes like productivity, resistance to biotic and abiotic stresses and processing; recent advances in breeding including biotechnological approaches; breeding objectives and advances made in ginger, turmeric, coriander, fenugreek, black pepper, cardamom etc.

Seed morphology, development, environmental factors responsible for belting and flowering; pollination systems, isolation, roguing and certification; seed production; storage and viability in important seed spices like fenugreek, coriander, cumin, fennel, etc.

3. POST HARVEST TECHNOLOGY

Post harvest physiology and biochemistry of fruits and vegetable; nutritive value and quality control; principles and causes of spoilage of horticultural products; principles

and methods of processing; fruits and vegetable processing; packaging science; dehydration and fermentation technology.

Importance of post harvest handling in fruit, vegetable, spice and plantation crops; Maturity indices for harvesting and ripening; pre-cooling, various types of storage and storage temperatures; grading, packing and transportation; Storage disorders and use of chemicals, skin coatings and growth regulators for control of spoilage during storage and transit.

Factors affecting bud development, flower development and senescence physiology and biochemical change during flower senescence, effect of pre-harvest factors on harvest quality of cut flower, stages of harvest of commercial flowers, decline in vase life, floral preservatives, pulsing and holding solution, grading packing, storage and transportation of cut flower.

Harvesting with reference of maturity indices, grading, packing including consumer packaging, transport, Different methods of storage, storage temperatures disorders. Pre and post harvest treatments to control disorders; value-added products of fruits, vegetables, tuber crops, spices and plantation crops.

4. FRUITS SCIENCE

Area, production and productivity of fruits crops in India; nutritional value and importance in national economy of fruit crops; origin, distribution and classification of fruits crops into temperate, tropical, sub-tropical, arid zone crops; classification of edible parts; regions of cultivation; export potential of different fruits; management of biodiversity and climate change.

Planning, layout and management of nurseries, soil mixtures, containers, soil sterilization, raising of seedlings, transplanting, packing and transport of nursery plants; importance of rootstocks, inter-stocks, apomixis and polyembryony; recent propagation techniques, method and time of propagation of different fruit crops; stionic incompatibility; role of chemicals in seed germination, root induction and seedling growth; propagation structures like mist chambers, hot beds and cold frames; advances in micro-propagation, shoot tip grafting.

Definition of growth and development; dormancy, rest period chilling requirements and heat units; physiology of flowering and chemical induction of flowering; fruit bud differentiation and fruit set, development, fruit drop and its control; parthenocarpy and seedlessness; role of auxins, gibberellins, cytokinins, ethylene, inhibitors and other growth retardants in fruit production.

Modern production technology of fruit covering soil and climate; propagation varieties; planting and population density; training and pruning; nutrition and irrigation; weed, disease and pest control including IPM and other orchard management practices of important fruit crops e.g. mango, citrus, banana, pineapple, papaya, guava, sapota, grape, litchi, pomegranate, ber, aonla, jackfruit, longan, olive, strawberry, apple, pear, stone fruits, etc.

Causes and recent advances in the control of alternate bearing, malformation, spongy tissue in mango; granulation and decline in citrus; bunchy top in banana; fruit drop and fruit cracking in citrus, mango, litchi and pomegranate; guava wilt: internal breakdown and bitter pit in apple, barrenness in grapes; management of biotic and abiotic stress

Principles, problems and prospects of fruit breeding; method of improvement e.g. introduction, clonal selection, hybridization, mutation breeding, polyploidy and heterosis breeding; breeding objectives, problems in improvement and advances made in important crops like mango, citrus, banana, grape, papaya, guava, apple, aonla and pomegranate, etc; advance in root stock breeding in apple, peach, pear, cherry, grape, citrus.

5. FLORICULTURE AND LANDSCAPE ARCHITECTURE

Importance, area, production and productivity; Importance of flower in national economy; Origin, distribution and classification of flowers e.g. cut, loose, dry flowers, pot plants; and classification of ornamental plants e.g. annuals, biennials, edges, hedges, shrubs, climbers, trees bulbous plant, foliage plants, succulents, cactus and water loving plants; regions of cultivation, import and export.

Selection of site; layout, rooting media and its sterilization; recent propagation techniques; stock and scion relationship, method and time of propagation; raising of seedlings, Transplanting pruning, grading, packing and marketing; role of chemicals in seed germination, root induction and seedling growth; use of propagation of structures. e.g. hot bed, cold frame, mist propagation chamber, plastic tunnels and green houses.

Soil and climate; varieties; population density (seed rate) and planting, nutrition, irrigation, training, pruning and staking, weed, disease and pest control of important flower e.g. rose, carnation, chrysanthemum, gladiolus, marigold, tuberose, gerbera, aster, orchids, iris, anthurium, lilies, tulip, lotus and begonia.

Definition of growth and development; dormancy and rest period, physiology of flowering and biochemical changes during flower senescence, effect of pre-harvest factors on post harvest quality of cut flowers, stages of harvest of commercial flowers, decline in vase life, floral preservatives, pulsing and holding solutions, grading packing, storage and transportation of cut flowers.

History of gardening in India; styles of gardening, their principles and practices with special reference to Mughal, Japanese, and English gardens; visual aspects of plants arrangement view; garden parts (features) their materials, and methods of garden development. Classification and utilization of ornamental trees, shrubs, climbers, annuals, edges, hedges, bulbous, succulents and cactus, foliage and water loving plants; preparation and management of shrubbery, herbaceous borders, lawn and bonsai; landscape gardening; planning of road side, home gardens, children, amusement and zoological parks; flower arrangement.

Principles of seed production, development, environmental factors for seed set, pollination system, isolation, rouging and certification, Hybrid seed production, seed harvesting, cleaning, storing, packing and marketing.

Principles, problems and prospects of ornamental plant breeding; methods of improvement i.e. introduction, clonal selection, hybridization for specific purposes, mutation breeding, polyploidy and heterosis breeding; breeding objectives and advances made in important crops like rose, gladiolus, carnation, chrysanthemum, marigold, aster, orchids, lilies, tulip, lotus, begonia and bougainvillea.

FACULTY OF AGRICULTURAL ENGINEERING

1. FARM MACHINERY AND POWER

Status of farm mechanization in India; power availability on farms; hand tools used for different kinds of farm operations and materials for construction. Functional requirement, principle of working, constructional features and operation of animal and power operated equipment for land development, tillage, sowing, planting, transplanting, fertilizer application, intercultivation, plant

protection, harvesting, threshing, mowing, chaff cutting and baling; special equipment for crops such as sugarcane, cotton, groundnut, potato and plantation crops like coconut, areca nut, cashew nut etc. Design and selection of machinery elements viz. gears, pulleys, chains and sprockets, belts, bearings, couplings and springs and fasteners. farm machine system characteristics and evaluation, dynamic balancing and stability of farm machines, force analysis on agricultural tools and implements, pull, draft, unit draft and power of farm equipment, design of soil working tools for sowing and planting; design of fertilizer applicators, intercultivation equipment, harvesters and threshers; pneumatic and hydraulic controls. Calibration of seed drills, planters, plant protection equipment; methods of testing and performance evaluation of tillage equipment, seed drills and planters, fertilizer applicators, sprayers and dusters, harvesting and threshing equipment, grain and straw combines, and special equipment such as sugarcane, cotton, rice and potato planter; calculations of field capacity, efficiency and rates of seed fertilizer and chemical applicators; calculation of capacity, efficiency and losses in threshers, harvesters and chaff cutters. Farm machinery selection and management for different soils, crops and operations; cost analysis of animal and tractor operated implements and tractors; matching power-implement system, estimation of energy and power requirements, reliability of farm machinery. Engineering thermodynamics, power cycles, fuels; various systems of IC engines; operations, adjustment and trouble shooting of different systems; calculations of power, torque, speed, firing arrangement and intervals, heat load and power transmission from piston to the flywheel; tractor power transmission, differential, final drives; power outlets such as P.T.O. and drawbar; recent trends in tractor design; emissions and control of pollutants; mechanical and power steering; tractor chassis mechanics, hitching systems, hydraulic controls for tractors, automatic position and draft control; tractor performance tests, operation and maintenance tractors and power tillers. Anthropometry in equipment design, physiological cost and effect of work on physiological responses, fatigue and comfort; ergonomics in design of farm tools; safety aspects of agricultural machinery; effect of noise and vibration on work performance; chemical hazards and control measures; operator's protective gadgets; design of tractor controls viz., hand and foot controls, visual range and limitations, seat design etc. Dynamic properties of soil and their measurements; stress-strain relationships; theories of soil failure, mechanics of tillage tools; design parameters and performance of tillage tools. Introduction to traction devices, tyre function and size, their selection, mechanics of traction devices, traction theories, slippage and sinkage of wheels, evaluation and prediction of traction performance; soil compaction - causes and methods for alleviating the effect on soil and crop responses. Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection, storage and applications; solar photovoltaic conversion and SPV powered systems. Types of wind mills and their applications; thermo-chemical conversion of biomass, direct combustion, Pyrolysis and gasification, chemical conversion processes, carbonization, briquetting, pelletization and densification of biomass; bioconversion into alcohols, methyl and ethyl esters, organic acids, solvents of amino acids; types of biogas plants, biogas properties, uses and distribution, alternate fuels for IC engines. Energy requirement in agricultural production systems, energy ratio and specific energy value, inflow and outflow of energy in unit agricultural operation, energy audit, accounting and analysis. Specification of materials, surface roughness, production drawing, computer aided drawing heat treatment, workshop practices applied in prototype production, common tools and press operations, metal cutting and machining, jigs, fixtures and gauges, casting and die-casting processes; basic joining processes, welding processes, weldments testing and metallurgy. Mechanical measurements, sensors and transducers, application of electrical strain gauges, signal transmission and processing, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power vibrations etc.; determination of calorific value, fluid flow rates etc; signal conditioning and monitoring, data acquisition and storage.

2. SOIL & WATER ENGINEERING

Water resources of India. Irrigation potential and contribution of groundwater, utilizable groundwater resources and level of groundwater development in the country, scope of groundwater development. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Hydraulics of fully and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Salt water intrusion in inland and coastal aquifers. Application of groundwater models for groundwater development and management. Conjunctive use of surface and groundwater. Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump and its classification. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution. Soil and water as vital resources for agricultural production. Water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting profile water storage. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential, significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD). Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Development of crop water deficit, crop adaptation to water deficit, morpho physiological effect of water deficit. Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements. Management strategies to improve crop productivity under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rain fed regions. Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Application of statistics in hydrology. Probability concepts. Distributions and application. Intensity duration frequency analysis. Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff estimation, hydrographs, S-hydrograph, IUH, unit hydrograph theory and its application, Flood routing methods and calculations. Soil erosion and types of erosion. Soil loss measurement and estimation. Universal soil loss equation and subsequent its modifications, soil and water conservation structures and their design. Gully control structures and their design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis of slopes. Mathematical models and simulation of hydrologic processes. Application of GIS in soil and water conservation. Watershed concept, Identification and characterization of watersheds. Hydrological and geomorphological characteristics of watersheds. Land capability and irrigability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, machineries and equipments for land levelling. History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and climatic parameters. Crop modeling , water production function. Methods of irrigation,

surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Application and distribution efficiencies. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Irrigation legislation. Irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management. Scope for economizing the use of water. Problem soils and their distribution in India. Water quality criteria and use of brackish waters in agriculture. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils and fish production. Agricultural field drainage and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. Design and installation of surface and subsurface drainage system. Interceptor and relief drains and their design. Drain pipe and accessories. Pumped drainage. Drainage requirements of crops. Drainage in relation to salinity and water table control. Reclamation of ravine, waterlogged, swampy areas and polders. Salt-affected soils and their reclamation. Command area development organizational structures and activities. River valley projects, interstate disputes. Water rights and legal aspects. Irrigation water users association concept and responsibilities. Environmental considerations in land and water resources management.

3. POST HARVEST & FOOD ENGINEERING

Uniqueness of bio-materials and physical characteristics *viz.* shape, size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose. Properties of bulk particulate solids *viz.* specific surface area, mean diameter, flow rate. Aerodynamics drag coefficient and terminal velocity. Pressure drop through 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.

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC, sorption and desorption isotherms, water activity and psychrometry. Modes of heat transfer, heat exchanger. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Dimensional analysis and simulation. Simulation models and mathematical modeling. Finite difference analysis, Finite element analysis. Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (evaporative, osmotic and freeze drying), pasteurization and sterilization of liquid foods, kinetics of microbial death, size reduction, cryogenic grinding, granulation, crystallization, filtration,

membrane processing, microfiltration, ultra-filtration, nano-filtration, reverse osmosis, evaporation, distillation, mixing, clarification, coagulation, mechanical separation, sedimentation, pressing, expelling, leaching, extraction, palleting, extrusion and industrial fermentation and processing. 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, downstream processing, bio-separation. Minimal processing of fruits and vegetables, high pressure processing, ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nano encapsulation 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 selection of standard parts (pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses)

Bulk conveying equipments *viz.* belt conveyors, screw/ auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement, damage to products during mechanical handling. Operation and maintenance of conveying equipment. Packaging material characteristics and selection. Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Cold chain design and operation. Refrigerated containers and trucks for perishable foods. Safety standards in handling, packaging and transport of agricultural produce. Storage environment and its interaction with stored product. Factors/parameters influencing the shelf life of the stored product, climatograph and deterioration index. Modeling of metabolic activities and predication of storage life, quality deterioration mechanisms and their control. Storage practices (including fumigation) for food grains. Design of bulk storage and aeration system. Analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, controlled and modified atmosphere storage systems and their design, smart storage system. Quality analysis of stored produce. Plant design concepts and general design considerations, plant location, product and process design, process flow charts, equipment selection, plant layout. Design and selection of machinery for handling utilities like water, steam, fuel etc. and disposal of effluents and residues. Static and dynamic characteristics of instruments, Transducers 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, Programmable logic controller, Data loggers, Data Acquisition Systems (DAS). Introduction to Direct Digital Control (DDC), Supervisory Control and Data Acquisition Systems (SCADA), and Virtual Instrumentation. Project development. market survey and time motion analysis. Selection of equipment, technology option, techno - economic feasibility. processing in production catchment. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning. BIS/ FSSAI/ ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.