16. SYLLABIFOR ENTRANCE EXAMINATION FOR Ph.D.

The Entrance Examination will be in the form of one question paper of three distinct parts. The questions will be of multiple choice and matching types in part I & II (30 marks and 150 marks, respectively) and short analytical type in part III (30 marks). Answers for part I & II are to be given on computerized OMR answer sheets (see **Annexure-VI**) and that of part III in the space provided for the purpose in the question paper. Negative marking to the extent of 0.25 marks for each wrong answer will be applicable in case of part I and II of the questions of the paper.

PART- I : GENERAL AGRICULTURE

Importance of Agriculture in national economy; basic principles of crop production; cultivation of major crops such as rice, wheat, pigeonpea, cotton, sugarcane, tomato, cauliflower, mango and rose.

Weathering of rocks; soil formation, major soils of India, soil erosion and its control; common farm implements; role of NPK and their deficiency symptoms; manures (FYM, compost and green manure) and fertilizers (urea, diammonium phosphate, single superphosphate and muriate of potash).

Structure and function and cell organelles - mitosis and meiosis; gametogenesis, fertilization and embryogenesis; chromosomal and extra-chromosomal basis of inheritance; mutation and polyploidy; selection methods, hybridization, backcross; plant growth regulators; plant metabolism photosynthesis, respiration and nitrogen fixation.

Isomerism; titrimetry and volumetry; structure and function of carbohydrates, proteins, nucleic acids, enzymes and vitamins.

Major pests and diseases of rice, wheat, maize, pulses, oilseeds, vegetables, cotton, sugarcane and their management.

Important principles of economics, structural transformation in economy and its globalization; principles of extension education; important rural development programmes in India; organizational

set up of agricultural research, education and extension in India, elements of statistics.

PART-II AND III: SUBJECT PAPER

AGRICULTURAL CHEMICALS (01)

Nomenclature and classification of organic compounds, chemical bonding; isomerism and stereo chemistry; properties and reactions of organic functional groups; aliphatic, alicyclic, aromatic and heterocyclic compounds; theory and application of chromatography and spectroscopy (IR, UV, NMR, Mass and tandem techniques) in the study of organic compounds; chemistry of natural products; terpenoids, steroids (cholesterol and Vitamin D), alkaloids (pyrrolidine, piperidine, pyridine, pyrrole groups), lipids, carbohydrates, plant pigments, nucleic acids, amino acids and proteins. Chemical equilibria; chemical kinetics, kinetic theory of gases, thermodynamics; surface chemistry, colloids, emulsions, solutions. Titrimetry, theory of indicators; redox reactions. Classification of pesticides; chemistry of botanical and microbial pesticides (pyrethroids, rotenoids, nicotinoids, neem, BT, bialaphos etc.) and synthetic insecticides (organochlorines, organophosphorus, carbamates etc.), fungicides (inorganic fungicides, dithiocarbamates, azoles, carboxamides, strobilurins etc.), herbicides (alkanoic acids, triazines, ureas, carbamates, anilides, sulfonyl ureas and imidazolinones etc.), fumigants (EDB, EDCT, aluminium phosphide), rodenticides (warfarin, bromadilone) and nematicide (triazophos, phenamifos, carbofuran etc.); pesticide formulation - definition and classification, characterization, specification, surfactants, quality control and application technology; concepts of pesticide residue chemistry, MRL, CODEX, ADI, NOAEL JMPR, regulation and quality control of pesticides, safety aspects including environmental fate, analytical techniques in residue analysis, decontamination and remediation techniques, good laboratory practices; nitrification and denitrification, nitrification inhibitor; N 2 -fixation; radioactivity and radiotracer techniques.

AGRICULTURAL ECONOMICS (02)

Basic concepts in economics, theory of consumer demand, theory of production, market classification, theory of perfect and imperfect competition, theory of distribution, national income accounting, classical and Keynesian theories of income determination, money-concepts, functions, theories of demand for money, supply of money; general equilibrium of product and money markets; IS and LM functions; monetary and fiscal policies, banking - central and commercial, functions and problems of recent macro-economic policies of Government of India; research methodology, steps in agricultural economics research, data collection, analysis and report writing; differential and integral calculus, differential equations, matrix algebra, solution of simultaneous linear equations, linear programming, statistical inference, correlation and regression analysis, time series analysis and theory of index numbers.

Nature and scope of agricultural production economics vis-a-vis farm management; farm business analysis, farm records and farm cost accounting; farm planning and budgeting, production function and resource allocation; cost, profit and supply functions; nature and analysis of risk in farming; systems approach in farming; role of credit in agriculture, principles of agricultural finance, farm financial management, supply and demand for farm credit; recent innovations in the extension of credit to agriculture, theory and practice of co-operation; problems of co- operatives, management of co-operative institutions; cost-benefit analysis of agricultural projects.

Scope of marketing in a developing economy; practice and problems of marketing agricultural inputs and outputs; functions and channels of marketing, co-operative marketing; agricultural price analysis; demand analysis; problems and prospects of storage and processing of agricultural products; agricultural exports - problems and prospects.

Theory of growth and growth models; agricultural policy, planning and development in India, inter-regional variations in agricultural development, agricultural technology and income distribution; agrarian reforms and output and input price policies; infrastructure and institutions for agricultural development, equity and ecological consideration in agricultural development.

AGRICULTURAL ENGINEERING (03)

Part A (Common for all three sub-disciplines/areas): 30 marks

Basic concepts in calculus, trigonometry, analytical geometry, linear algebra and algebra of real and complex numbers; instrumentation for measurement of forces, torque, temperature, moisture, fluid flow; basic principles of simulation; methods of statistics, dynamics and mechanics of materials; common distributions of random variables and methods of statistical inference; energy sources - their utilisation and efficiencies on the farm; uses and application of computers and electronics including sensors in agriculture, energy management and sustainable renewable energy sources, climate change impacts and resilient agriculture.

In addition to Part A, attempt any one of the following three sub-disciplines

Part B : (120 Marks)

In addition, attempt any one of the following three areas depending upon the major field of choice.

i. **Agricultural Processing and Structures:** Application of engineering properties in designs; principle of heat transfer, boundary layer and turbulence; mass transfer operations, mechanisms of moisture movement; theory of drying, equilibrium moisture content; methods of storage and milling; design of material handling devices; mechanical separation; design consideration in farm structure and animal housing; seed processing equipments; plant layout, Materials for different agricultural structures, BIS Standards on practices, equipment and design of storage structures.

ii. **Farm Power and Equipment**: State of farm mechanization; testing of power units and tractor systems; performance capacities of power and machines on the farm; management of power and machinery and their use on the farm; dynamics of machine elements; soil dynamics in tillage and traction, tillage and tractor machines; design considerations in farm machinery and power units; tractor hydraulics, symbols and circuits; ergonomics and safety consideration in machine design, production technology and manufacturing processes.

iii. **Soil and Water Conservation Engineering**: Water resources and history of irrigation in India, major irrigation projects, irrigation potential from different sources, fluid mechanics, aquifers and their characteristics, ground water hydraulics, groundwater recharge, wells and pumps, water lifting devices, energy for groundwater pumping, salt water intrusion in inland and coastal aquifers, groundwater models, groundwater development and management, flow through porous media, vadose zone processes, soil moisture characteristics, field capacity, permanent wilting point, available soil water for plant, soil water potential, collection, analysis and interpretation of hydrological data; application of statistics in hydrology, runoff mechanism, hydrograph, food routing, principal and practices of irrigation and drainage, crop water requirement, irrigation requirement, soil-plant-water relationships, irrigation scheduling, plant water potential, water movement through soil plant atmosphere system, hydraulics of furrow, check basin and border irrigation, hydraulic design of pressurized irrigation system, irrigation efficiencies, quality of irrigation water, design and operation of irrigation projects, drainage investigations, drainage characteristics of various types of soils, drainage coefficient, design and installation of surface and subsurface drainage system, management of salt affected soils, soil erosion; soil conservation measure; soil and water conservation structures and their design, design and construction rainwater harvesting structures, models for simulation of hydrologic process, application of GIS in land and water management, stream gauging and sediment monitoring; watershed management; open channel flow, hydraulics of open channel floe, energy and momentum principles, specific energy, hydraulic jump, design of different types of irrigation channels, irrigation water measurement, lining of waterways and canals; stability of slopes and design of earthen dams.

AGRICULTURAL EXTENSION (04)

Concepts, objectives, philosophy and principles of extension education; Genesis and growth of Extension; Extension systems, reforms, innovations, organizational structures in India; Classification of extension approaches; Comparative studies of extension in developed and developing countries; Features of pluralistic extension- public, private, public-private partnership, corporate social responsibility; Agricultural Information (Knowledge) System; Extension methods; e-extension.

Teaching-learning processes, learning theories, pedagogy and andragogy, experiential learning, instructional technologies; Programme planning- principles, processes and tools; Agricultural and rural development programmes and schemes in India.

Principles of Extension management; Theories, processes and functions of management; MBO, Total Quality Management, Organizational Behaviour; Training for Human Resource development, Training design, methods, models and typologies; Training need assessment; Training *vs* Education.

Entrepreneurship development, Agri-business and market-led extension; Concepts and theories of psychology applied in extension education; Socio-psychological dimensions of human behavior, Socio-psychological factors associated with technology transfer and behavioural change; Social structure; Process of socialization, social interactions and processes; Social change; Values and norms; Rural institutions; Farmers' groups, associations, cooperatives and producer companies; Group dynamics; Gender empowerment and related issues.

Concepts, models, and process of communication; Theories of communication; Mass communication and Agricultural journalism; Information and Communication Technology; Audio-visual aids; Diffusion and adoption of innovations; Grassroots innovations and indigenous technical knowledge.

Elements and process of social research; research typology, Concepts and postulates of measurement; Qualitative and Quantitative techniques of measurement; Research design; Sampling methods; Testing of hypothesis; Scales and tests; Reliability and validity of measuring instruments; Methods of observation and data collection; Statistical methods and Tests of significance; Participatory tools and techniques for rapid appraisal and learning; Tools and techniques for monitoring, evaluation and impact assessment.

AGRICULTURAL PHYSICS (05)

Forms of energy; conservation of mass, energy and momentum; thermodynamics; radioactivity and its applications in agriculture; colligative properties; structure and physical properties of water; molecular forces; principles of spectroscopy. Electromagnetic radiation: visible, infrared, microwave and their application to remote sensing in agriculture; spectral signature of natural targets and spectral indices; sensors and platforms; GIS and GPS. Weather and climate; atmosphere and its constituents; meteorological elements and their measurements; heat balance of the earth and atmosphere; crop weather interactions; climate change and greenhouse effect; evapotranspiration; climatic classification: Koppen and Thornthwaite systems; climatology of India, agro- ecological regions, monsoon, western disturbances, cyclones, droughts. Soils of India; factors and processes of soil formation; physical, physicochemical, and biological properties of soils; soil water retention and movement under saturated and unsaturated conditions; infiltration, redistribution and evaporation of soil water; field water balance and water use efficiency; soil aeration; thermal properties of soil and heat transport; influence of soil water, temperature and aeration on crop growth and their management; soil erosion and control.

AGRICULTURAL STATISTICS (06)

Elements of probability theory, concepts of random variable and distribution function, conditional probability; Bayes' theorem; moments; moment generating and characteristic functions; Chebychev's inequality, law of large numbers; limit theorems; univariate (discrete and continuous) distributions; sampling distributions, transformations; multivariate normal distribution, Wishart's distribution, Hotelling's T2; discriminant function; elements of stochastic processes; theory of point estimation; Cramer-Rao inequality; Rao-Blackwell theorem; methods of estimation; confidence intervals; testing of hypothesis, tests of simple hypothesis against simple or composite hypothesis; likelihood ratio test; sequential probability ratio test; large sample tests; non-parametric tests.

Concepts of sampling and non-sampling errors; simple random sampling; stratified sampling, allocation of sample to strata gain due to stratification; ratio and regression methods of estimation; cluster sampling; two stage sampling; systematic sampling; sampling with probability proportional to size with replacement.

Principles of design of experiments; uniformity trials; completely randomized, randomized block and Latin square designs; missing values in randomized block and Latin square designs; analysis of non-orthogonal data in two-way classification (without interaction); factorial experiments and confounding in symmetrical factorial experiments - design and analysis of 2n and 3n experiments; split and strip plot designs; balanced incomplete block design (BIBD)- parametric relations and

general properties; analysis of BIBD with recovery of interblock information.

Statistical analysis for segregation and linkage; random mating and equilibrium in large populations; inbreeding- effects of finite population size; polygenic systems for quantitative characters; genetic variance and correlation; heritability, repeatability; individual, family and combined selections; selection for improving several characters; cross-breeding.

AGRONOMY (07)

Principles of crop production, crop plants in relation to environment, growth analysis concepts; quantitative agro-biological principles and their validity; classification of climate, agro-climatic zones of India; physiological limits of crop yield and variability in relation to the agro-ecological optimum; Tillage - concepts and practices. Principles and practices of weed management in crops and cropping systems; weed biology and ecology, crop weed competition, herbicide classification, selectivity, mode of action and herbicide resistance, integrated weed management. Introduction, origin, history, production, distribution, cultural practices, varieties, quality, biomass production and bioenergetics of field crops, forages, spices and condiments crops. Soil fertility and its management; essential plant nutrients, their functions and deficiency symptoms in plants; organic manures, chemical and biofertilizers. History of irrigated agriculture, soil-water-plant relationship, soil moisture stresses and management; drought resistance in crops, drought tolerance/resistance-mechanism and management; soil and plant moisture conservation techniques, water harvesting and other agrotechniques for dryland agriculture; measurement of soil moisture, irrigation scheduling and methods, quality of irrigation water; watershed management, agricultural drainage; problem soils - saline, alkali, saline-alkali and acid soils, genesis, characteristics and management; wasteland management, soil erosion and its control. Cropping systems - principles and practices; changing cropping patterns in different agro-climatic zones; sustainability - concept and practices; agro-forestry systems - concepts and practices. Modern concepts in agronomy- Conservation agriculture, precision nutrient and water management, organic farming, contract farming, integrated farming system, agronomic biofortification, etc. Basic statistics and principles of experimental designs, methods of statistical analysis and data interpretation.

BIOCHEMISTRY (08)

Importance of biochemistry in plant sciences; plant cell structure, cell organelles and their function; chemistry of bonding, isomerism, free energy, enthalpy and entropy; pH and buffers.

Enzymes and enzyme kinetics; structure, function and immobilization of enzymes; metabolism of carbohydrates, proteins, lipids and nucleic acids; structure and function of vitamins and hormones; metabolism of secondary plant products; nitrate assimilation and biological nitrogen fixation; sulphur metabolism; photosynthesis and respiration.

DNA replication, transcription, and translation, regulation of gene expression in eukaryotes and prokaryotes; viruses and bacteriophages; basic concepts of genetic engineering and its application in crop improvement; elementary concepts of immunology.

Fundamental principles of nutrition, balanced diet, calorie and protein requirement, nutritive value of foods. Chromatography, electrophoresis, isoelectric focusing; ultracentrifugation; radio isotopic techniques in biochemical studies; spectrophotometry and ELISA.

BIOINFORMATICS (09)

Nucleic acids as genetic material; chemistry, structure and function of DNA and RNA, Genome organization in prokaryotes and eukaryotes; DNA replication, Transcription process; RNA processing; RNA editing; Genetic code; Translation and post-translational modifications, Function of genes and genomes; Nucleic acid hybridization; PCR and its applications. Genomics, transcriptomics and proteomics. Molecular markers in basic and applied research; Genetic engineering and transgenics; General application of biotechnology in agriculture.

Genomic and proteomic databases: NCBI/ EBI/EXPASY etc.; SWISSPROT, UniProtKB, PIR-PSD, PDB, Prosite, BLOCKS, Pfam/Prodom etc. Concepts of sequence analysis, Pairwise sequence alignment algorithms: Needleman &Wunsch, Smith & Waterman, BLAST and FASTA. Scoring matrices for Nucleic acids and proteins: PAM, BLOSUM. Multiple sequence alignment. Sequence

based gene prediction and its function identification. Protein structure prediction and homology modelling. Molecular dynamics simulation and docking. Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins using molecular visualization softwares such as RasMol, Cn3D, SPDBV, Chime, Mol4D etc. Phylogenetic trees and their comparison, Phylogenetic analysis algorithms: Maximum Parsimony, UPGMA, Neighbor-Joining.

Theory of probability. Random variable and mathematical expectation. Probability distributions: Binomial, Poisson, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions. Population genetics: Hardy –Weinberg law, Effect of systematic forces on changes in gene frequency. Foundations for Machine learning Techniques: Unsupervised and Supervised Learning, Cross Validation Techniques, Markov Model, Hidden Markov Model.

Computer programming languages: Perl, Bio Perl and Java programming, Object oriented programming, classes, objects, Data types, Operators and expressions. Data encapsulation, Polymorphism, Inheritance. Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification. Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML).

COMPUTER APPLICATION (10)

Computer organization and architecture - Boolean algebra, Number system, Basic concepts of floating point number system, Sequential and combinational circuits, Input/Output unit, Memory Organization, ALU and Control unit, Instruction and execution cycle in CPU, Introduction to microprocessors, Interrupts, CISC and RISC Architecture.

Programming language (C++/JAVA) – Computer algorithms, Flow Charts, Encapsulation, Inheritance, Polymorphism, Building blocks, Control structures, Arrays, Pointers, Dynamic memory allocation, File management, Graphics.

Internet programming- Hyper Text Markup Language (HTML), Building static and dynamic web pages, Client side and server side scripting languages, Interaction with database.

Data structures – Representation of character, string and their manipulation, Linear list structure, Stack, Queue, Heaps, Linked list, Arrays, Tree, Graph, Sorting and Searching algorithms.

Software engineering – Requirement analysis and specification, Software Development Phases, Process models, Project structure, Project team structure, Role of metrics, Measurement, Software quality factors, Coding tools and techniques, Testing, Maintenance, Gantt charts, PERT and CPM, CASE tools.

Networking – Types of Networks, Network topology, Network Operating Systems, Network Management, Data communication and transmission, ISO-OSI reference model, TCP/IP reference model, Internet standards and services, Cryptography, Data compression, Authentication and firewalls.

Compilers and translators – Regular expression, Finite automata, Formal languages, Finite state machines, Lexical analysis, Semantic analysis, Parsing algorithms, Symbol tables, Error handling, Intermediate code optimization, Machine code generation, Machine dependent optimization.

Operating system – Process management: Inter-process communication, Process scheduling; Memory management: Swapping, Virtual memory, Paging and segmentation; Device management: Deadlocks, Semaphores; File systems –Files, Directories, Security and protection mechanisms; Distributed operating systems.

Data base management system – Definition and features, Data models, Relational database: Logical and physical structure, Relational algebra, Relational calculus, Database design, Normalization, Concurrency control, Security and integrity, Query processing and optimization, Indexes, Backup and recovery; Distributed Databases – Concepts, Architecture, Design; Structured Query Language (SQL), PL/SQL.

Numerical analysis – Interpolation, Numerical integration, Solution of ordinary differential equations, Solution of linear and non-linear system of equations; Statistical methods – Summarization of data, Frequency distribution, Measures of central tendency, Dispersion, Skewness and kurtosis, Test of significance based on normal, chi-square, t and F distributions, Curve fitting,

Point estimation.

ENTOMOLOGY (11)

Position of insects in animal kingdom - their origin, phylogeny and distribution; diagnostics of insect Orders and economically important families; concept of species, speciation and biotypes; rules and regulations of zoological nomenclature; current concepts of insect classification; DNA barcoding. Morphology and anatomy; embryonic and post-embryonic development. Insect ecology - biotic potential, , effect of biotic and abiotic environmental factors on insect development and population dynamics, life table analysis, population modelling, remote sensing applications diapause, food chain, migration and dispersal; climate change impacts on insects. Fundamentals of insect physiology- different systems, their structure and function, metabolism; host plant selection, insect nutrition and role of symbionts,; Classification, mode of action and metabolism of insecticides; basics of insecticidal formulations and residues; plant products, antifeedants, hormones, growth regulators, semiochemicals; pest outbreaks and resurgence; insecticide resistance and management; plant protection appliances. Biological control-parasites, predators and pathogenic microorganisms of crop pests; ecological engineering; host-plant resistance; genetic engineering. Insect quarantine, invasive species, national and international plant protection organizations. Social and other beneficial insects. Principles of integrated pest management; pests of field crops, horticulture and stored products, vector management, management of non- insect pests including vertebrate pests.

ENVIRONMENTAL SCIENCES (12)

Fundamentals of components of environment - atmosphere, hydrosphere, geosphere, biosphere, pedosphere and their interaction, energy flow in ecosystems; ecosystems and agro ecosystems of the world; biogeographic regions; soil as a biological habitat; distribution and types of soil organisms and their significance in soil productivity; bio-geochemical cycles in different ecosystems; agro-ecological regions of India; global climatic change- basics, greenhouse gases, impact of climate change on agriculture, ecosystems; adaptation and mitigation options; current environmental issues; international conventions and negotiations on climate change and environment; Natural disaster management, biotic and abiotic interactions and their significance; natural resources - effect of anthropogenic factors on the degradation of natural resources; conventional and nonconventional sources of energy; environmental issues in agriculture and environmental impact assessment; environmental auditing; environmental pollution and agricultural productivity; Biodiversity; environmental microbiology; ecosystem services; soil, water and air pollution and their remediation; inter-relationships of crop and animal production systems with environmental pollution in different eco-systems; waste management; environmental laws; basics of simulation modelling and its applications, analytical techniques for major environmental pollutants; spectrophotometry, chromatography; basic chemodynamics of environmental pollutants; advanced environmental monitoring techniques; basic statistics; chemistry of fossil fuels, fluorocarbon, nitrogen, carbon, halogens, phosphorus, heavy metals and their compounds; pesticides and other hazardous chemicals, basic photochemistry.

FLORICULTURE AND LANDSCAPE ARCHITECTURE (13)

Importance and scope of floriculture, principles and elements of landscaping, garden styles and designs, annuals, shrubs, climbers, trees, foliage plants, cacti, succulents, palms, ferns, bonsai and their suitability in landscaping. Propagation techniques including tissue culture in ornamental plants, turfgrass management, origin, classification and floral biology of flower crops, factors affecting growth and flowering of ornamental plants.

Production technology of rose, chrysanthemum, gladiolus, carnation, gerbera, orchids, lilium, jasmine, tuberose, marigold, antirrhinum, bougainvillea, China aster, fillers and cut greens under open and protected conditions, breeding of flower crops. Role of male sterility, self-incompatibility, polyploidy and mutations in crop improvement. Heterosis breeding and development of F1 hybrids in flower crops, seed production and biotechnology in flower crops. Pre and post harvest factors affecting life of flowers, post harvest management of flowers, value addition in flower crops, flower arrangement. Role of growth regulators in flower crops.

Important statistical designs; methods of their statistical analysis, general principles of fruits and

vegetable production, major methods of preservation and processing of horticultural and ornamental crops.

FRUITS SCIENCE (14)

Area and production of fruits, climatic and soil requirements, cultivation practices of major fruit crops like mango, citrus, banana, grape, papaya, litchi, guava, pineapple, jackfruit, sapota, cashewnut, coconut, ber,pomegranate, date palm, aonla, underutilised and minor fruit crops, temperate fruits like apple, pear, peach, almond, plum, apricot, walnut and cherry; Systematics of fruit crops; Ideotypes, breeding approaches and achievements in fruit crops through conventional and non-conventional techniques, Pollinizers and pollination management in fruit crops; Physiology of growth and development of fruit crops; modern methods of propagation including micropropagation and use of growth regulators in fruit crops; Principles of pruning and training, canopy management; weed control; rootstocks and high density orcharding; Nutrient and water management; use of biofertilizers and bioagents for safe fruit production; physiological manipulations for overcoming problems like biennial bearing, spongy tissue, malformation in mango, delayed maturity and uneven ripening in grapes and granulation in citrus; biotic and abiotic stress management in fruit crops such as guava wilt, citrus decline, bacterial blight in pomegranate, Thanjavur wilt in coconut etc; Maturity standards and ripening physiology of fruit crops; Important statistical designs; methods of their statistical analysis; general principles of flower and vegetable production; major methods of preservation and processing of horticultural crops.

GENETICS AND PLANT BREEDING (15)

Structure and function of cell and cell organelles, cell cycle; mitosis and meiosis; nucleic acids - their structure; Mendelian principles; chromosome structure and organization; types of chromosomes; chromosome function; linkage and crossing over - theories and molecular mechanism; recombination and gene mapping in diploids, fungi, bacteria, and human; ploidy variations - euploids and aneuploids; chromosomal aberrations; extrachromosomal inheritance; gene mutation-mechanism, induction; gene concept; complementation, genetic fine structure; genetic code, information transfer and protein synthesis, gene regulation and gene manipulation; gene transfer technology; origin and evolution of important crop plants like wheat, rice, maize, sugarcane, potato, brassica, cotton, etc.

Genetic basis of plant breeding; pure line selection; male sterility and incompatibility and their use in plant breeding; pedigree selection, mass selection and backcross method of selection; heterosis; plant introduction and exploration and their role in plant breeding; breeding for disease, insect and pest resistance; role of interspecific and intergeneic hybridisation; population improvement procedures; recurrent selection techniques; combining ability and its relationship with the components of gene action; seed production techniques; selection methods and changes in gene frequencies; mutation and its role in breeding; use of biotechnology in plant breeding. Molecular markers and their applications in genetic analysis and plant breeding.

MICROBIOLOGY (16)

Origin and development of microbiology; classification of bacteria, fungi, algae, protozoa; microscopy; methods of isolation, pure cultures, enumeration, sterilization, preservation; morphology and reproduction in bacteria, fungi, actinomycetes, algae, viruses.

Microorganisms in food, fermented foods; spoilages of food; food - borne diseases; microbial pollution of air and water; water purification; energy and metabolic pathways in microorganisms; fermentation and industrially useful microbial processes - citric acid, lactic acid, ethanol, vinegar, production of antibiotics, enzymes, vitamins, amino acids; mutations and genetic recombination, transformation, transduction and conjugation; soil microorganisms and their activities; rhizosphere and phyllosphere; microbial association, microbial decomposition of organic wastes, composting and biogas; nitrification and denitrification; symbiotic and non-symbiotic nitrogen fixation; microbial transformation of phosphates; use of microorganisms and biofertilizers.

MOLECULAR BIOLOGY AND BIOTECHNOLOGY (17)

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; transcription and translation; recombinant DNA, restriction enzymes, vectors, plasmids, cosmids and bacteriophages, expression vectors, cloning strategies, construction and screening of genomic and cDNA libraries, nucleic acid hybridisation and DNAsequencing; restriction fragment length polymorphism; monoclonal antibodies and their application; enzyme engineering; genetic transformation of eukaryotes; crop improvement through genetic engineering; role of tissue culture in crop improvement; microbes in agriculture and industry; structure and function of proteins, nucleic acids, carbohydrates, lipids, enzymes; metabolism, glycolysis, citric acid cycle; respiration, bioenergetics; nucleic acid and protein biosynthesis; photosynthesis, nitrogen fixation.

NEMATOLOGY (18)

History of Indian and world Nematology, importance of nematodes in agriculture and public health; techniques in nematology (microscopy, extraction of nematodes from different habitats, population estimation, handling of nematodes, staining, processing, microtomy, experimental method for proof of pathogenicity, culturing of nematodes, bioassays of nematicides, screening of crop genotypes against plant parasitic nematodes and basic molecular techniques); diversity of nematodes, classical and molecular phylogeny, nematode taxonomy, broader classification of nematodes, identification of plant and soil nematodes, general morphology of nematodes, insect-parasitic nematodes, and model nematodes. Biology and physiology of nematodes, types of parasitism, basic and applied aspects of plant –nematode interaction, symptomatology, histopathology and host specialization. Plant diseases caused by nematodes, nematode interaction with other pathogens, ecological factors influencing nematode activities and population dynamics; principles and methods of nematode control and management, recent advances in nematode management.

PLANT GENETIC RESOURCES (19)

Biodiversity and agricultural intensification; origin and history of agriculture; ecosystem diversity, ecological basis of genetic variations and adaptation; domestication, introduction and adaptation of economically important plants; centres of crop plant origin and diversity; taxonomy of cultivated plants; origin, evolution, global distribution and economic use of important cereals, pulses, oilseeds, fruits, vegetables, commercial crops and medicinal plants; Indian Gene Centre; genetic variation in crop plants and management of germplasm collections - principles of collecting plant genetic resources (PGR), Crop wild relatives - sampling strategies, parameters of genetic diversity; principles and strategies of germplasm regeneration - considerations for regeneration of self and cross-pollinated crops; characterization, diversity analysis and evaluation of plant germplasm using morphological, biochemical and molecular approaches; DNA fingerprinting; strategies of PGR conservation - *ex situ* and *in situ* conservation, biotechnological approaches for conservation - *in vitro* conservation, cryopreservation; seed structure, physiology, biochemistry and storage biology; policy issues - exchange of PGR, plant quarantine, GMOs and biosafety issues, IPR related aspects; national and international programmes, global plant genetic resources networks.

PLANT PATHOLOGY (20)

Landmarks and pioneers of plant pathology; microscopy and staining; structural and physiological differences amongst fungi and fungi like organism, bacteria, rickettsias, phytoplasma and spiroplasma, viruses and viroids; principles of culturing and preservation of pathogens; characteristic symptoms; host pathogen interaction; symbiosis; economically important diseases of crop plants induced by fungi and fungi like organism, bacteria, phytoplasma and spiroplasma, viruses and viroids; phanerogamic parasites, non-parasitic diseases; nutrition, growth, reproduction, life cycle, ultrastructure, genetics, nomenclature and classification of fungi, bacteria, viruses and other plant pathogens; Mendelian principles; cell structure; origin of life and evolution; beneficial microorganisms including mycorrhiza; variation in phytopathogens and their ecology; epidemiology; transmission; detection and diagnostic methods for pathogens; host resistance; seed -borne pathogens and plant quarantine; chemical and biological control, integrated management practices and advances in disease management.

PLANT PHYSIOLOGY (21)

Atoms, molecules and ions; molarity, molality and normality; pH, buffers, solutions and colloids; permeability, diffusion and osmosis; cell structure and function; structure and metabolic role of cell organelles; concept of water status, water potential and its components, water uptake, transpiration, stomatal physiology, xylem and phloem transport; enzyme - mode and mechanism of action; structure and function of chloroplast; photosynthetic pigments, photosystems, electron transport, ATP synthesis, C3, C4 and CAM pathways; redox potential; photorespiration, chemosynthesis, photosynthetic efficiency, glycolysis, HMP, TCA and glyoxylatecycles; macro - and micro-nutrient elements and their functions, deficiency symptoms, role in metabolism; foliar nutrition; nitrogen metabolism including nitrate reduction, ammonia assimilation, transamination, protein synthesis, nitrogen fixation; carbohydrate metabolism; sulphur metabolism; fatty acid and lipid synthesis and degradation; secondary metabolites; plant hormones - biosynthesis and catabolism, signalling and role in plant growth and development including stress responses; photoperiodism, vernalization and flowering, florigen concept; light receptors-phytochrome, cryptochrome, phototropins; sex expression; Abscission, senescence and PCD; seed physiology; dormancy; growth analysis, measurement of key growth functions such as NAR, LAI, RGR, growth response in relation to environmental factors; crop canopies and light utilization; source-sink relationship, dry matter partitioning; physiological basis of crop productivity - case histories of some crop plants viz, cereals, grain legumes and oilseeds; environmental stresses viz, high and low temperature, light, water, salinity and alkalinity, their terminology and measurement techniques, Phenotyping methods, abiotic stress signalling, mechanisms of stress responses in plants; environmental pollution, green house effects; post harvest physiology, ripening mechanism; molecular biology of plant processes, response to environmental and developmental cues, growth and development; basic principles of methodology/instrumentation in plant physiological research e.g., chromatography, spectroscopy, centrifugation, radioactivity, electrophoresis, hydroponics, tissue culture.

POST HARVEST TECHNOLOGY (22)

Choose any one the following sub-disciplines:

i. Post Harvest Technology for Horticultural Crops

Role of fruits and vegetables in human nutrition; Pre-harvest treatments in relation to postharvest quality of horticultural produce; Biochemical changes in fruits and vegetables with special reference to ripening: role played by ethylene, respiration and transpiration; Important nutrients and enzymes associated with fresh and stored fruits and vegetables; storage of fresh fruits and vegetables; Post harvest management of horti produce-maturity indices, handling, packaging, storage-methods and structures; Post-harvest treatments (HWT, VHT, irradiation, bioagents); Novel molecules (salicylic acid, nitric oxide, 1-MCP); Postharvest diseases, disorders and their management; Various methods of fruit and vegetable preservation: heat processing, dehydration, refrigeration, freezing and chemical preservation, hurdle technology etc; Advances in food processing techniques: microwave heating, vacuum impregnation, HPP, PEF, Ultrasonics; Processed horticultural products and packaging; Spoilage of processed products; Food quality evaluation techniques; Food contaminants Food Safety & Standards; Utilization of horticultural wastes; Postharvest technology of commercially important plantation crops (coconut, cashew, oil palm, cocoa); Bio-technological tools (genes/enzymes/GM crops) for enhancing quality and shelf-life of horti-crops; Important statistical designs and methods of their statistical analysis.

ii. Post Harvest Engineering and Technology

Thermodynamics applied to food processing; Fluid flow analyses; Similitude and Dimensional analysis; Instrumentation involved in food engineering; Heat and Mass transfer; Design of heat exchangers; Mass and energy balance; Losses at different stages of the food chain; Cleaning, Sorting and Grading; Drying; Size reduction; Mechanical separation: Sieving, Clarification, Filtration, Sedimentation; Leaching; Evaporation; Distillation; Crystallization; Coagulation; Mixing; Densification: Granulation and briquetting, Pelletization; Parboiling; Shelling/Dehusking/Decorticating; Milling of cereals, pulses and oilseeds; Pressing and Expelling; Extrusion, Stabilization and Cryogenics; Machineries for processing of agricultural products- cereals, pulses, oilseeds, fruits and vegetables; Handling and packaging of fresh and processed agro produce; Grain storage structures: On-farm and commercial storage structures for agricultural produce; Design of structure and equipment for handling, storage and packaging of agricultural produce; Test of

hypothesis, multiple regression; fundamentals of computers; Cost scheduling and appraisal; PERT and CPM techniques.

SEED SCIENCE AND TECHNOLOGY (23)

Cell structure and function; cell division; pollination, fertilization and embryogenesis; apomixis; Mendelian principles; linkage; recombination and gene mapping; ploidy variations - euploids and aneuploids; chromosomal aberrations; extra-chromosomal inheritance; mutation; genetic basis of plant breeding; pure line, pedigree and mass selection; backcross and recurrent selection techniques; heterosis and combining ability; male sterility and incompatibility and their use in plant breeding and hybrid seed production; chemical composition of seeds; biosynthesis of carbohydrates, proteins and fats; mechanism and factors determining seed germination and dormancy; germination inhibitors and promoters; endogenous hormonal regulation of germination and dormancy; breaking of dormancy; seed vigour and viability; seed quality concept; system of seed quality control; testing, release and notification of varieties, deterioration of varieties; maintenance of genetic purity; area of seed production; management of hybrid seed production - isolation and synchronization of flowering; role of insect pollinators and their efficiency; factors responsible for mechanical injury to seed; seed legislation; seed certification - concept and procedures; measurement of seed quality; metabolic changes associated with seed deterioration; seed packaging, storage and marketing; insect ecology; principles of insect control in field crops; integrated pest management; fumigation and chemical treatment for pest control in store; fungal, bacterial and viral seed borne diseases of cereals, pulses, oilseeds and vegetables and their control; seed moisture; seed drying and processing; history of seed industry in India; national and international organisations for seed quality control and trade.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY (24)

Rocks and minerals; mineral weathering and soil formation; Soil taxonomy, classification of soils, major soils of India, soil survey; principal silicate structures; nature and properties of organic and inorganic constituents of soils, ion exchange phenomenon; activity of ions in soil system; fixation and release of nutrients. Soil fertility evaluation; movement of water; problem soils, soil-related constraints in crop production and remedial measures, soil amendments; soil and water conservation; sampling and analytical procedures for soils, plants, water, manures, fertilizers and soil amendments; quality of irrigation water; fertilizer recommendations; soil organic matter, soil microflora; carbon, nitrogen and phosphorus cycles; biofertilizers; phosphate solubilization; Darcy's law; Fick's law, steady and transient state diffusion in soils. Essential plant nutrients; manures; utilization of organic wastes and industrial by-products; fertilizers and their production, properties and usage; secondary and micronutrients; soil pollution, chemical and bio-remediation of contaminated soils.

VEGETABLE SCIENCE (25)

Area and production of vegetable crops in India, climatic and soil requirements, seed production techniques in vegetable crops and related problems.

Origin, classification, cytogenetics, floral biology and breeding behaviour of different vegetables; methodology for the improvement of different self-and cross-pollinated vegetable crops including breeding for disease and insect resistance;Mendel'slaws ofinheritance.

Role of different nutrients, their deficiency symptoms and remedial measures; improved vegetable production technology.

Important statistical designs and methods of statistical analysis general principles of fruits and flower production; major methods of preservation and processing of horticultural crops.

WATER SCIENCE AND TECHNOLOGY (26)

Water resources of India, physical, chemical, biological properties of water; irrigation development in India; command area development; Basic concepts of soil physics and fluid mechanics; infiltration theory; seepage; Darcy’s law; Bernoulli's theorem; hydraulic conductivity; soil water flow; composition of atmosphere and its constituents; soil air, thermal properties of soil; climate characterization, climatic change, flood, monsoon, precipitation, water harvesting; ground water recharge and conservation; various types of droughts, drought indices, drought management,

water budgeting.

Evaporation; evapotranspiration; crop water requirement; plant growth processes; water stress in plant; irrigation scheduling; field water balance; soil-plant-water relationship; irrigation methods, irrigation efficiencies, water distribution networking (large and moderate scale); water measurement and conveyance structures; pressurized irrigation system and its design.

Surface and ground water quality; national and international water quality standards; irrigation with poor quality water, waste water management, surface and sub-surface drainage system, drainage for salinity control, drainage effluent management.

Ground water hydraulics, geophysical techniques in ground water, surface hydrology, hydrometeorology; watershed management; soil and water conservation practices and design; irrigated water resource management; degradation of soil and water resources and their mitigation measures.

Water rights; water laws; water disputes; water pricing; water users associations; use of remote sensing and GIS in water resource management; decision support system, expert system for planning and operation of water resources.