Ph. D. Syllabus in the Department of Crop Physiology

Course No.	Title	Credit
CPH 600	Research methodology and techniques	4+0
CPH 601	Physiology of growth and yield modelling	4+0
CPH 602	Advances in stress physiology	4+0
CPH 603	Hormonal regulation of plant growth and development	4+0
CPH 604	Seed physiology	4+0
CPH 605	Molecular approaches for improving physiological traits	4+0

CPH 600: Research methodology and techniques 4 +0

Objectives:
To orient the scholars regarding various growth analysis parameters, agro-meteorological observations, to handle about different laboratory equipments.

Syllabus:
UNIT-I
Definition, objectives and types of research; Research process; Criteria of Good Research; Nature and scope of crop physiological research; Defining research problems; Research Project Planning and Management.

UNIT II
Biometric observations; Analysis of crop growth – recording dry matter, measuring leaf area; Concept of growth analysis parameters – CGR, RGR, LAI, NAR etc.
UNIT III
Agro-meteorological observations – data recording, analysis, presentation and interpretation. Correlation studies of weather data and crop growth.

UNIT-IV
Laboratory techniques used physiological research; Basic knowledge of working in laboratory; Basic principles of laboratory techniques commonly used in physiological research; Recent experimental techniques to study various physiological processes.

UNIT-V
Basic principles of experimental design; Data processing and analysis – multiple correlation and regression, analysis of variance and covariance. Test of significance – t test, z test, F test.

UNIT-VI
Interpretation of result – concept of least significant difference (LSD), DMRT, contrast analysis, missing plot techniques; Graphical and tabular presentation of data.

UNIT-VII
Research ethics and need of scientific temper: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT-VIII
Computer application in crop physiological research; Use of different softwares for statistical analysis of data.

Learning Outcomes:
Students will understand about different methodologies of plant physiological research; students will understand the principles of different laboratory equipments; the knowledge in research methodology acquired by the students will be useful for carrying out research in the subject

CPH 601 Physiology of growth and yield modelling 4+0

Objectives:

To orient the scholars regarding applications in crop physiological research; physiological basis of yield variation in crop plants and know about yield modelling.

UNIT I
Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

UNIT II
Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

UNIT III
Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

UNIT IV
Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

UNIT V
Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning

efficiency and harvest index. Crop growth models-empirical models testing and yield prediction.

UNIT VI

Practical on Field measurement of root-shoot relationship in crops at different growth stages; Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth; Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized; Computation of harvest index of various crops; Assessment of crop yield on the basis of yield attributing characters; Construction of crop growth curves based on growth analysis data; Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping; Senescence and abscission indices; Analysis of productivity trend in un-irrigated areas; Analysis of productivity trend in irrigated areas.

Learning Outcome:

Students will understand about different aspects of crop growth analysis and their applications in crop physiological research; students will understand the physiological basis of yield variation in crop plants; the knowledge in yield modelling acquired by the students will be useful for predicting yield of crops.

CPH 602 Advances in stress physiology 4 +0

Objectives:

To impart basic knowledge about different aspects of stress physiological processes and their applications in agricultural research; to impart knowledge the physiological and molecular basis of abiotic stress tolerance in plants and climate resilient crops

Syllabus:

UNIT I

Stress and strain terminology; nature and stress injury and resistance; causes of stress, Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity.

UNIT II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, Tolerance mechanism-crucial role of membrane lipids, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

UNIT II

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, Tolerance mechanisms- role of membrane lipids and HSPs, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT III

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, physiological processes affected by drought; Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants, Osmotic adjustment, Osmoprotectants, Stress proteins; Practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

UNIT IV

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, physiological consequences, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

UNIT V

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, practical ways to overcome the effect of salt stress through soil and crop manipulations.

UNIT VI

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution. Heavy metal stress: Aluminum and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

UNIT VII

Global warming; Climate change and its impact on crop growth and development; Carbon sequestration

UNIT VIII

Practical on Determination of electrical conductivity of plant cell sap and soil water; Determination of osmotic potential and tissue water potential; Measurement of transpiration rate; Measurement of stomatal frequency; Determination of proline content of plant parts.; Determination of Relative Leaf water content of plants; Quantification of anti-oxidative enzymes like *Super oxide desmutase* (SOD);Determination of membrane injury index(MII);Determination of chlorophyll stability index (CSI);Studying the role of growth regulators in amelioration of abiotic stress effects in plants; Determination of soil water potential and content by psychrometry and other systems; Studies on effect of osmotic and ionic stress on seed germination and seedling growth.

Learning Outcome:

1. Students will understand about different aspects of stress physiological processes and their applications in agricultural research
2. Students will understand the physiological and molecular basis of abiotic stress tolerance in plants
3. The knowledge in stress physiology acquired by the students will be useful for

development of climate resilient crops

CPH 603 hormonal regulation of plant growth and development 4+0

Objectives:

To provide basic information about different aspects of phytohormones and plant growth regulators and their applications in agriculture; physiological functions and mechanism of action of various plant hormones and knowledge in plant growth regulation acquired by the students will be useful for achieving higher productivity of crops

Syllabus:

UNIT I
Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols –polyamines, jasmonates, concept of death hormone.

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

UNIT III
Hormone mutants and transgenic plants in understanding role of hormones.

UNIT IV
Signal perception, transduction and effect at functional gene level of different hormones-Auxins- cell elongation, Gibberellins-germination of dormant seeds, Cytokinins-cell division. Retardation of senescence of plant parts, Abscisic acid-stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

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

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

UNIT VII
Practical on Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins-bioassays- auxins effect on rooting of cuttings, abscission, apical dominance,

Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin-bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bioassays estimation using immunoassay technique. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

Learning Outcome:

1.Students will understand about different aspects of phytohormones and plant growth regulators
and their applications in agriculture
2. Students will understand the physiological functions and mechanism of action of various plant hormones
3. The knowledge in plant growth regulation acquired by the students will be useful for achieving higher productivity of crops

CPH 604 Seed physiology 4+0

Objectives:
To impart knowledge different aspects of seed physiology and their applications in agricultural research; understand the physiological and biochemical basis of dormancy and seed germination.

Syllabus:

UNIT I
Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

UNIT II
Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

UNIT III
Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT IV
Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT V

Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

UNIT VI

Control processes in mobilization of stored resources, Role of embryonic axes, Gibberellins and α-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VII

Seed viability, Physiology of and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

UNIT VIII

Practical on Determination of seed storage proteins, Sink drawing ability of ovules, empty ovule technique, Alpha-amylase activity in germinating seeds, Role of GA in inducing amylase activity, Role of embryo in GA induced α-amylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds, Seed respiration rates, and Seed viability losses through membrane leakage studies.

Learning Outcome:

1.Students will understand about different aspects of seed physiology and their applications in agricultural research

2. Students will understand the physiological and biochemical basis of dormancy and seed germination.

3. The knowledge in seed physiology acquired by the students will be useful for achieving higher crop stand

CPH 605 Molecular approaches for improving physiological traits 4+0

Objectives:

To provide knowledge about various aspects of plant physiology and molecular biology; different techniques of molecular biology and knowledge about climate ready crops.

Syllabus:

UNIT I

Importance of Molecular Breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding. Physiological traits with relevance to growth, development, abiotic stress tolerance, nutrient acquisition, Approaches for accurate phenotyping oflarge germplasm accessions and/or mapping populations.

UNIT II

The advantages of "Trait based" breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of Dominant and Co-dominant marker systems.

UNIT III

Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure.

UNIT IV

Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc.

UNIT V

Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining

UNIT VI

Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.

UNIT VII

Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes.

UNIT VIII

Transformation of crop plants-*Agrobacterium* and use of other organisms for transformation-particle gun transformation and other methods. Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events.

UNIT IX

Evaluation of transgenics on basis of empirical/physiological/biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.

UNIT X

Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

UNIT XI

Practical on Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Statistical approaches to assess genetic variability, heritability and other parameters, Phylogenic analysis, Principal component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis, Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system, Crop transformation - *Agrobacterium* mediated transformation (in planta & invitro), particle-gun transformation, Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

Learning Outcome:

1. Students will understand various aspects of plant physiology and molecular biology
2. Students will be able to know about different techniques of molecular biology
3. The knowledge in molecular biology acquired by the students will be useful for development of clime ready crops.
