Ph. D. Syllabus in the Department of Agronomy

Sl. No.	Course code	Name of the course	Credits
1	AGR 600	Research methodology and techniques	4+0
2	AGR 601	Crop production and system modelling	4+0
3	AGR 602	Advances in crop growth and productivity	4+0
4	AGR 603	Advances in soil fertility management	4+0
5	AGR 604	Advances in irrigation management	4+0
6	AGR 605	Advances in weed management	4+0
7	AGR 606	Integrated farming systems for sustainable agriculture	4+0
8	AGR 607	Soil conservation and watershed management	4+0
9	AGR 608	Stress crop production	4+0
10	Course III	Review of research work and written presentation of synopsis	4+0

AGR 600 Research methodology and techniques 4+0

Objectives:

To familiarize students with basics of research and the research process, to enable the participants in conducting research work and formulating research synopsis and report, to familiarize participants with statistical techniques and interpretation of results, to impart knowledge for enabling students to develop data analytics skills and meaningful interpretation to the data sets so as to solve the research problem.

Syllabus:

UNIT I
Definition, objectives and types of research; Research processes, Criteria of Good Research, Nature and scope of agronomic 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; Economics and energetics of cop production.

UNIT III
Agro-meteorological observations – data recording, analysis, presentation and interpretation. Correlation studies of weather data and crop growth.

UNIT IV
Laboratory techniques involved in soil and plant analysis. Basic knowledge of working in laboratory. Basic principles of laboratory techniques commonly used in agronomic research. Collection of soil and plant samples and processing for laboratory analysis.

UNIT V
Basic principles of experimental design; Lay out of field plot 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; analysis of cropping system data – intercropping and sequential cropping. Graphical and tabular presentation of data.

UNIT VII
Importance and need of scientific temper, values and ethics in research: 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 agronomic research; Statistical analysis of data by using softwares.

Learning Outcome:
Upon successful completion of the course participants are expected to develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling, have basic knowledge on qualitative and quantitative research techniques, have basic awareness of analysis and presentation of data.

AGR 601 Crop production and system modeling 4+0

Objectives:

To familiarize the students about elementary models for crop growth, system approaches and to simulate yields and growth of crops under varied soil and weather conditions particularly under climate change with different management practices and their optimization.

Syllabus:

UNIT I
Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams.

UNIT II
Elementary models for crop growth based on basic methods of classical growth analysis.

UNIT III
Crop modeling methods for crop-weather interaction, climate change and variability components.

UNIT IV
Potential production: leaf and canopy CO2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

UNIT V
Production by moisture availability ,potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

UNIT VI
Practical on Simulation of elementary models for crop growth, Simulation of potential, production, Simulation with limitations of water and nutrient management options, Sensitivity analysis using different climatic years and crop management practices

Learning Outcome:
Upon successful completion of the course students are expected to develop understanding on the techniques of development of elementary models for crop growth, simulation of crop growth and production under limited water and nutrient management options, production potentials and sensitivity analysis under various climatic and crop management practices.

AGR 602 Advances in crop growth and productivity 4+0

Objectives:

To impart in-depth ideas of the physiology of different crops under various environments in relation to the productivity, techniques of growth analysis, assessment of growth and yield and analysis of productivity trends in different agroecological situations.

Syllabus:

UNIT I of
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:

Upon successful completion of the course participants are expected to develop understanding on the techniques of growth analysis, prediction of crop growth and yield and development of optimum crop management strategies to achieve expected yield, analysis of productivity trends under irrigated and rainfed conditions.

AGR 603: Advances in soil fertility management 4+0

Objectives:
To impart in-depth knowledge on modern concepts of plant nutrient availability, fertilizer evaluation, nutrient use efficiency, soil fertility and its evaluation, soil productivity under long term intensive cropping and to apprise about the advances in the techniques of nutrient analysis in soil and plant samples.

Syllabus:

UNIT I
Modern concepts of nutrient availability; nutrient response functions and availability indices. Importance of root morphology in nutrient availability.

UNIT II
Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III
Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV
Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V
Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer recommendations; site-specific nutrient management for precision agriculture, Use of SPAD chlorophyll meter and LCC as tools of fertilizer N management.

UNIT VI
Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

UNIT VII
Fertilizer use in problem soils; Fertilizers and environmental pollution; Soil health and quality; phytoremediation.

UNIT VIII
Practical on Design of soil fertility experiments; Collection and processing of soil and plant samples for nutrient analysis; Handling of common laboratory equipments used for soil and plant sample analysis; Analysis of soil samples for soil pH, organic carbon, available nitrogen, available phosphorus, available sulphur, lime requirement, electrical conductivity; Analysis of plant samples for nitrogen, phosphorus, potassium and sulphur; Soil fertility experimental data analysis and interpretations; Correlation and regression studies of plant nutrient and crop growth and yield; Determination of soil biomass carbon; Determination of micronutrients in soils and plants by AAS; Visit to long term fertilizer experiment stations.

Learning outcome:

Upon satisfactory completion of the course participants are expected to develop knowledge of fertilizer evaluation, nutrient budgeting in different crops according to soil condition, understand essentiality of plant nutrients and mechanism of nutrient transport to plant and factor affecting nutrient availability, to be able about procedure of soil testing and establish soil testing laboratory in future as an entrepreneur.

AGR 604 Advances in irrigation management 4+0

Objectives:

To impart in-depth knowledge about soil, plant water relationships, strategies of optimization of irrigation under limited water supply, consumptive use and water requirement of cropping systems under variable agroclimatic conditions.

Syllabus:

UNIT I
Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

UNIT II
Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological process and crop productivity.

UNIT III
Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

UNIT IV
Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in design and operation of irrigation projects; irrigation management in principal crops and cropping system; quality of irrigation water and management of saline water for crop production.

UNIT V
Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirations; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

UNIT VI
Land suitability for irrigation, land irrigability classification; integrated water management in command areas, farmer's participation in command areas, irrigation legislation.

UNIT VII
Practical on Determination of water infiltration characteristics and water holding capacity of soil profiles; Moisture extraction pattern of crops; Consumptive use, water requirement of a given cropping pattern for optimum / variable productivity; Crop planning at the farm and project level; Agronomic evaluation of irrigation projects, case studies.

Learning Outcome:
Upon successful completion of the course participants are expected to develop understanding on the techniques of irrigation management in major crops and cropping systems, strategies of optimum utilization of limited water supply and develop skill of agronomic evaluation of irrigation projects.

AGR 605: Advances in weed management 4+0

Objectives:

To impart advanced knowledge about causes and effect of changes in weed flora, advances in herbicide application techniques, use of new generation herbicides, their phytotoxicity, herbicide resistance and integrated weed management in different crops and cropping systems.

Syllabus:
UNIT I
Crop weed competition in different cropping situations; changes in weed flora, various causes and effects; integrated weed management in major cropping systems.

UNIT II
Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

UNIT III
Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides; adjuvants.

UNIT IV
Advances in herbicide application techniques; antidotes and crop protection; compatibility of herbicides of different groups; compatibility of herbicides with other pesticides, herbicide development, registration procedures.

UNIT V
Recent advances in herbicide resistance in weed and its management; development of transgenic herbicide resistant crops; invasive weeds, aquatic and parasitic weeds and their management; advances in weed utilization.

UNIT VI
Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides and herbal herbicides, allelochemicals, herbicide bioassays.

UNIT VII
Practical on Phytosociological analysis of weed flora in major cropping system; Studies on propagule production potential of major weeds; Determination of critical period of crop weed competition; Studies on mode of action of herbicides; Economic utilization of weeds; Herbicide bioassays.
Expected Learning outcomes: Upon satisfactory completion of the course students will be able to develop comprehensive ideas about recent advances in the approaches of weed management, biology, ecology of major weeds, recent advances in the concept of

herbicide selectivity, herbicide resistance, knowledge on selection of specific herbicides in different crops and cropping systems and planning for integrated weed management strategies.

AGR 606 Integrated farming systems for sustainable agriculture 4+0

Objectives:
To apprise about the new concepts and approaches of farming systems, efficient farming systems, selection of different enterprises suitable for different agroclimatic situations for sustainable agriculture.

Syllabus:

UNIT I
Farming systems: definition, concept and scope; Components of farming systems in plains and hills; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization and mechanization, water supply, enterprises. Integrated farming systems.

UNIT II
Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III
Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.
UNIT IV
Simulation models for cropping systems; agronomic management in different cropping systems; preparation of different farming system models; evaluation of different farming systems.

UNIT V
New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Learning Outcome:

Upon successful completion of the course the student will be able to explain the concept of sustainability in farming systems, preparation of farming system models under different agroecological situations, develop knowledge of agronomic management of different cropping systems and have the exposure of different farming systems of various agroclimatic zones.

AGR 607 Soil conservation and watershed management 4+0

Objectives:

To apprise about different soil moisture conservation techniques, watershed management, concept of alternate landuse systems, techniques of preventing soil erosion, drainage and agronomic management for enhancing the agricultural productivity through holistic approach.

Syllabus:

UNIT I
Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

UNIT II
Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; contingent crop planning; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III
Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas. Farming systems in watershed areas.
UNIT IV
Land use capability classification, alternate land use systems; agro-forestry; ley farming; jhum management - basic concepts, Drainage and agronomic management; Measures to prevent soil erosion.

UNIT V
Practical on Study of different types of erosion; Field studies of different soil conservation measures; Run-off and soil loss measurements; Laying out run-off plot and deciding treatments; Identification of different grasses and trees for soil conservation; Visit to a soil conservation research centre, demonstration and training centre.

Learning Outcome:

Upon successful completion of the course participants are expected to develop understanding on the techniques soil moisture conservation, watershed management, preventing soil erosion, drainage and agronomic management for enhancing the agricultural productivity through holistic approach and development of suitable farming systems in watershed areas.
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AGR 608 Stress crop production 4+0

Objectives:

To impart detailed ideas about various types of abiotic stresses and environmental pollution in relation to crop production and practical ways and means to overcome stresses and prevent environmental pollution.

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 III
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 IV
Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

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

UNIT VI
Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

UNIT VII
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 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:
Upon successful completion of the course participants are expected to develop understanding on causes and effect of various abiotic stresses and environmental pollution in relation to crop production and to develop suitable strategies for adaptation and mitigation of stresses and to prevent environmental pollution for successful crop production.

Course III Review of research work and written presentation of synopsis 4+0

Objectives:

To apprise the participants about evaluation and synthesis of the relevant literature within a specific field of research, the current state of thinking on the selected research topic and to identify research gaps and articulates how a particular research project addresses the gap.

Learning Outcome:

Upon satisfactory completion of the course participants are expected to evaluate and synthesis the current existing literature on the selected research topic, finalize and prepare synopsis of the proposed research work.