AMRITA VISHWA VIDYAPEETHAM

Syllabus

Ph.D. in Agronomy

Major Courses

25AGR601- Current Trends in Agronomy 3 0 0 3

Course Overview

To acquaint the students about modern innovations, sustainable practices, and advanced technologies in agronomy for enhancing crop production and resource management.

Course Outcome:

After learning the course, the students should be able to:

CO1	Explain the agro-physiological factors influencing crop yield and the latest advancements in soil-plant-water relationships.
CO2	Analyse the impact of globalization, WTO policies, and marketing systems on agricultural practices, including organic and contract farming.
CO3	Evaluate modern technologies in crop production such as precision agriculture tools, mechanization, and GIS/remote sensing applications.
CO4	Appraise conservation agriculture principles and strategies for sustainability under climate change scenarios.
CO5	Develop research approaches in agronomy to address current issues in dryland farming, seed technology, Conservation Agriculture and integrated farming systems.

Theory Syllabus

Unit I

Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship.

Unit II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming.

Unit III

Crop residue management in multiple cropping systems; latest developments in plant management: Mechanization in crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

Unit IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

Unit V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefitsof CA under climate change scenario, policy issues.

Text Books

1. Reddy, S.R. (2012). *Principles of Agronomy*. Kalyani Publishers, Ludhiana.
2. Brady, N.C. and Weil, R.R. (2016). *The Nature and Properties of Soils*. Pearson Education, New Delhi.
3. Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. (1999). *Soil Fertility and Fertilizers*. Prentice Hall, New Delhi.
4. Prihar, S.S. and Sandhu, B.S. (1987). *Irrigation of Field Crops – Principles and Practices*. ICAR, New Delhi.
5. Hegde, D.M. (2019). *Advanced Agronomy*. ICAR-Indian Institute of Oilseeds Research, Hyderabad.

Reference Books

1. Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.
2. Dahiya BS and Rai KN. 1997. *Seed Technology*. Kalyani.
3. Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.
4. ICAR. 2006. *Hand Book of Agriculture*. ICAR.
5. Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.
6. Palaniappan SP and Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.
7. Sen S and Ghosh N. 1999. *Seed Science and Technology*. Kalyani.
8. Tarafdar JC, Tripathi KP and Kumar M. 2007. *Organic Agriculture* Scientific Publ.
9. Kumar, R, Swarnkar KS, Singh KS and Narayan S. 2016. *A Text Book of Seed Technology*.Kalyani Publication.
10. Reddy SR and Prabhakara G. 2015. *Dryland Agriculture*. Kalyani Publishers.
11. Gururajan B, Balasubhramanian R and Swaminath V. 2013. *Recent Strategies on Crop Production*. Kalyani Publishers.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25AGR602- Recent Trends in Crop Growth and Productivity 2 0 1 3

Course Overview

To study the physiology of vegetative and reproductive growth in relation to the productivity of different crops across various environments.

Course Outcome:

After learning the course, the students should be able to:

CO1	Explain key physiological processes influencing crop growth and yield.
CO2	Compute and interpret growth parameters and competition indices in cropping systems.
CO3	Analyse yield advantages and constraints in intercropping and dryland farming.
CO4	Evaluate crop production systems and make recommendations to improve resource use and productivity.

Syllabus

Theory

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.

Practical

- 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
- 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

Text Books

1. Chopra VL and Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. OXford & IBH.
2. Delvin RM and Vitham FH. 1986. *Plant Physiology*. CBS Publ.
3. Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.
4. Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.

Reference Books

1. Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. OXford & IBH.
2. Gupta US. 1988. *Progress in Crop Physiology*. OXford & IBH.
3. Kramer PJ and Boyer JS. 1995. *Water Relations of Plant and Soils.* Academic Press.
4. Mukherjee S and Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.
5. Narwal SS, Politycka B and Goswami CL. 2007. *Plant Physiology: Research Methods.* Scientific Pub.
6. Tiaz L. and Zeiger E. 2006. Plant Physiology. Sinauer Associates, Inc.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR603-Irrigation Management 2 0 1 3

Course Overview

To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe global and Indian water resources, irrigation systems, and factors affecting irrigation needs.
CO2	Explain soil-water-plant relationships, water movement in soil, and principles of evapotranspiration and water use efficiency.
CO3	Analyse crop water requirements, irrigation scheduling, and methods to optimize limited water supplies for sustainable crop production.
CO4	Design irrigation systems (drip, sprinkler), drainage channels, and integrated water management plans using modern tools and economic analysis.

Syllabus

Theory

Unit I

Global water resources; Water resources of India, Indian River systems catchment and command areas and interlinking of rivers linking projects. Irrigation projects during pre and post-independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil. Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

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

Unit VIII

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

Unit IX

Economic analysis of irrigation and crop planning for optimum use of irrigation water

Unit X

Crop water production function. IoT and AI based applications in irrigation management

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination Moisture extraction pattern of crops
- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop efficient of one important crop
- Planning, designing and installation of drip irrigation system
- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies
- Determination of irrigation timing under different methods of irrigation
- Visit to irrigation command area

Text Books

1. MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
2. Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

3. Mishra RR and Ahmad M. 1987. *Manual on Irrigation and Agronomy*. OXford & IBH.
4. Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
5. Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. OXford & IBH.

Reference Books

1. Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). Production and Improvement of Crops for Drylands. OXford & IBH
2. Reddy SR. 2000. Principles of Crop Production. Kalyani.
3. FAO. 1984. Irrigation Practice and Water Management. OXford & IBH.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR604- Recent Trends in Weed Management 2 0 0 2

Course Overview

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the biology, ecology, and mechanisms of weed invasion and crop–weed competition in various cropping systems.
CO2	Explain the physiological and biochemical behavior of herbicides, including absorption, translocation, mode of action, selectivity, and environmental fate.
CO3	Analyze herbicide compatibility, resistance development, and integration with other crop management practices for effective weed control.
CO4	Develop advanced weed management strategies, including transgenic crops, bioherbicides, and innovative non-chemical methods.

Theory

Unit I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion - present status and factors influencing weed invasion.

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, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

Text Books

1. Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi)
2. Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.
3. Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.
4. Walia US. 2006. *Weed Management*, Kalyani.

Reference Books

1. Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
2. Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development*.*Mode of Action*, *Targets*, *Genetic Engineering*, *Chemistry*. Springer.
3. Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture, B. D. Sci. Pub*
4. Jugulan M, (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
5. Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25AGR605- Integrated Farming Systems for Sustainable Agriculture 2 0 0 2

Course Overview

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the concepts, classification, and components of Integrated Farming Systems under various agro-ecological conditions.
CO2	Explain the principles of sustainability, economic viability, and resource management in Integrated Farming Systems.
CO3	Analyse the production potential, component interactions, and adaptability of different Integrated Farming System models.
CO4	Design Integrated Farming System models incorporating organic farming, waste recycling, and sustainable development practices.

Theory

Unit I

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

Unit II

Concept of sustainability in Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources - identification and management.

Unit III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming systems based on land situations and climatic condition of a region; evaluation of IFS.

Unit IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different Integrated Farming system Models; evaluation of different Integrated Farming system models. Recycling of organic waste in farming system, in IFS.

Unit V

New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of Green House gases; case studies/ success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system. Aligning agriculture research with sustainable development goals.

Text Books

1. Jayanthi C. 2006. *Integrated Farming systems-A way to sustainable Agriculture*. Tamil Nadu Agricultural University, Coimbatore
2. Kolhapure A and Madhukar D. *A text book of farming system and sustainable agriculture*.
3. Panda SC. 2004. *Cropping systems and Farming Systems*. Agribios.
4. Ravisankar D and Jayanthi C. 2015. *Farming systems: concepts and approaches*. Agrobios,

Refence Books

1. Lampin N. 1990. *Organic Farming*. Farming Press Books.
2. Palaniappan SP and Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.
3. Joshi M and Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.
4. Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. OXford & IBH.
5. Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. *Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience*. Omni Scriptum Gmbh & Co. KG, Germany.
6. Balasubramanian P and Palaniappan SP. 2006. *Principles and Practices of Agronomy*. Agrobios.
7. Edens T. 1984. *Sustainable agriculture and integrated farming system*. Michigan State Univ. press.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25AGR606- Soil Conservation and Watershed Management 2 0 1 3

Course Overview

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Course Outcome:

After learning the course, the students should be able to:

CO1	Identify and discuss the types, causes, and influencing factors of soil erosion, along with key principles of soil and water conservation.
CO2	Explain and differentiate various agronomic and mechanical methods for soil conservation, assessing their suitability in different contexts.
CO3	Examine watershed management strategies, land capability classifications, and alternative land use systems for sustainable resource management.
CO4	Develop conservation plans and management practices for controlling erosion, improving drainage, and restoring degraded lands.

Theory

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; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; 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.

Unit IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

Unit V

Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Practical

- Study of different types of erosion
- Determination of dispersion ratio

- Estimation of soil loss by Universal Soil Loss Equation
- Estimation of soil loss by wind erosion
- Measurement of runoff and soil loss
- Field studies of different soil conservation measures
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to watershed areas
- Visit to a soil conservation research centre, demonstration and training centre

Text Books

1. Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. OXford & IBH.
2. Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.
3. FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.,* Paper 57.
4. Gurmel Singh, Venkataraman CG, Sastry B and Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. OXford & IBH.

Reference Books

1. Frederick RT, Hobbs J, Arthur D and Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection.* 3rd Ed. Prentice Hall.
2. Murthy VVN. 1995. *Land and Water Management Engineering*. Kalyani.
3. Tripathi RP and Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.
4. Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR607- Stress Crop Production 2 0 1 3

Course Overview

This course examines abiotic stresses affecting crops, their physiological impacts, and practical management strategies to mitigate them.

Course Outcome:

After learning the course, the students should be able to:

CO1	Define and describe various types of abiotic stress, their causes, and plant responses.
CO2	Explain the physiological and biochemical effects of water, temperature, salt, and mechanical stresses on crop growth.
CO3	Analyse the effectiveness of different soil and crop manipulation practices in mitigating specific stress conditions.
CO4	Design practical strategies for managing abiotic stress in crops through experimental techniques.

Theory

Unit I

Stress and strain terminology; nature and stress injury and resistance; causes ofstress.

Unit II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcomethe 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, 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

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

Unit VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to eXcess water.

Text Books

1. Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.
2. Nilsen ET and Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.
3. Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.

Reference Books

1. Baker FWG.1989. *Drought Resistance in Cereals*. OXon, UK.
2. Gupta US. (Ed.). 1988. *Physiological Aspects of Dryland Farming.* OXford & IBH.
3. Kramer PJ.1983. *Water Relations of Plants*. Academic Press.
4. Mavi HS.1978. *Introduction to Agro-meteorology*. OXford & IBH.
5. Michael AM and Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.
6. Singh KN and Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.

7. Somani LL and Totawat KL. 1992. *Management of Salt-affected Soils and Waters.* Agrotech Publ.
8. Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. OXford & IBH.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

Minor Courses

25AGR514 - Fundamentals of Agricultural Meteorology 2 0 1 3

Course Overview

To impart theoretical and practical knowledge of physical processes occurring inatmosphere and techniques used in meteorology.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the scope, components, and importance of agricultural meteorology in relation to crop production and management.
CO2	Explain the influence of meteorological parameters on plant physiological processes, drought prediction, and soil-water balance.
CO3	Apply weather forecasting methods, crop weather calendars, and agromet advisories in planning agricultural operations.
CO4	Develop suitable mitigation strategies to reduce the impact of climate change, air pollution, and greenhouse gas emission from agricultural landscapes

Theory

Unit I

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

Unit II

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

Unit III

Crop weather calendars; weather forecasts for agriculture at short, medium and long-range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

Unit IV

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation, meteorological aspects of forest fires and their control.

Unit V

Climatic change, greenhouse effect, CO_2 increase, global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical

Preparation of crop weather calendars - Development of simple regression models for weather, pest and disease relation in different crops - Preparation of weather based agro-advisories - Use of automated weather station (AWS).

Text Books

1. Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. OXford Book Co.
2. Mahi and Kingra. 2014. *Fundamentals of agrometeorology*. Kalyani publishers.
3. Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

Reference Books

1. Kakde JR. 1985. *Agricultural Climatology.* Metropolitan Book Co.
2. Mavi HS and Tupper. 2004. *Principles and applications of climate studies in agriculture*. CRC Press

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR515 - Crop-Weather Relationships 2 0 0 2

Course Overview

To study and understand the role of weather on crop growth and development.

Course Outcome:

After successful completion of this course, students will be able to:

CO1	Explain how weather elements and climatic variability influence crop growth and production.
CO2	Analyse the climatic requirements and effects of temperature, radiation, humidity, and wind on major crops.
CO3	Apply meteorological indices and weather forecasts to improve agricultural operations and productivity in diverse systems.

CO4	Evaluate the role of weather in rhizosphere processes, nutrient dynamics, and water use efficiency for sustainable crop management.

Theory

Unit I

Understanding the influence of weather elements on crop growth, impact of climatic variability and extremes on crop production, climatic normals for crop production.

Unit II

Climatic requirements of major crops, temperature effect on crop growth, radiation impact and radiation utlilization efficiency, humidity effect on crop performance, effect of soil temperature on seed germination and root growth, wind variation and crop growth.

Unit III

Meteorological indices to predict crop production, Interpretation of weather forecasts for various agricultural operations towards improved productivity, crop-weather relationship in dryland areas. Crop weather relationship of major horticultural crops of the region and agroforestry system.

Unit IV

Rhizosphere and microorganisms in relation to weather, fertilizer and water use efficiency in relation to weather.

Text Books

1. Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
2. Prasada Rao GSLHV. 2008. *Agricultural Meteorology*. PHI Learning Publishers.

Reference Books

1. Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.
2. Jerry L. Hatfield, Mannava VK, Sivakumar and John H. Prueger. 2017. *Agroclimatology: Linking Agriculture to climate.* Agronomy Monographs 60.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25AGR516 - Crop Micrometeorology 2 0 1 3

Course Overview

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere and within crop canopy concerning crop growth.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the processes involved in the exchange of mass, energy, and momentum between the Earth's surface and the lower atmosphere.
CO2	Assess microclimatic variations in soil and crop environments under different cultivation and weather conditions.
CO3	Utilize micrometeorological instruments and techniques to measure energy balance, radiation, and canopy characteristics.
CO4	Modify microclimate through interventions towards enhanced crop growth and development, and yield across different production systems.

Theory

Unit I

Properties of atmosphere near the Earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection.

Unit II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement, temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raymonds analogy, Exchange coefficients.

Unit III

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

Unit IV

Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b)

tall crops; energy balance over crops and LAI and biomass estimation; remote sensing and its application in relation to micrometeorology.

Practical

- Micrometeorological measurements in crop canopies
- Quantification of crop microclimate
- Determination of ET and its computation by different methods.

Text Books

1. Goudriaan J. 1983. *Crop Micrometeorology: A Simulation Study*. Scientific Publ.
2. Gupta PL and Rao VUM. 2000. *Practical Manual on Micrometeorology*. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
3. Jones HG. 1992. *Plants and Microclimate*. Cambridge Univ. Press. Munn RE. 1970. Biometeorological Methods. Academic Press.
4. Rosenberg NJ. 1974. *Microclimate – The biological Environmet*. John Wiley & Sons.

Reference Books

1. Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. OXford Book Co.
2. Chang, Jen-Hu. 1968. *Climate and Agriculture: An Ecological Survey*. Aldine Publishing Company.
3. Gates DM. 1968. *Energy Exchange in the Biosphere*. UNESCO.
4. Grace J. 1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman &Hall.
5. Monteith and Unsworth. 2013. *Principles of Environmental Physics*. Elsevier.
6. Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR517 - Evapotranspiration and Soil Water Balance 2 0 1 3

Course Overview

To impart the theoretical and practical knowledge of ET estimation anddetermination of the components of soil water balance

Course Outcome:

After learning the course, the students should be able to:

CO1	Explain the principles of soil water movement, hydraulic conductivity, and evapotranspiration processes under different soil moisture conditions.
CO2	Compare various methods used to estimate evapotranspiration and assess their suitability in different agroclimatic situations.
CO3	Analyse the influence of microclimatic and management factors on soil water balance and irrigation scheduling.
CO4	Apply advanced measurement techniques, including remote sensing, for estimating evapotranspiration and evaluating water use efficiency.

Theory

Unit I

Energy concept of soil water, hydraulic conductivity and soil water flux; Theory on hydraulic conductivity in saturated and unsaturated soils; physical factors concerning water movement in soil; concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.

Unit II

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration - modified techniques.

Unit III

Influence of microclimatic and cultural factors on soil water balance; techniques of lysimetry in measuring actual evapotranspiration. water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, computation of Kc values and their use; irrigation scheduling based on climatological approaches.

Unit IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; estimation of evapotranspiration through remote sensing.

Practical

- Measurement of various components of soil water balance
- Evaluation of hydraulic conductivity vs. soil moisture relationship by water balance approach
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Soil moisture retention characteristics by pressure plate method.

Text Books

1. Burman R and Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.
2. Niwas R, Singh D and Rao VUM. 2000. *Practical Manual on Evapotranspiration.* Dept. of Agril. Meteorology, CCS HAU Hisar.
3. Subramaniam VP. 1982. *Water balance and its application*. Andhra University Press, Waltair, India.

Reference Books

1. Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
2. Mavi HS and Tupper GJ. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
3. Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.
4. Rosenberg NJ, Blad BL and Verma SB. 1983. *Microclimate –The Biological Environment*. John Wiley & Sons.
5. Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR518 - Crop Weather Models 1 0 2 3

Course Overview

To impart the theoretical and practical knowledge of various models for estimationof crop weather responses.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the fundamentals of crop production and analyze how different weather factors and climate variability influence crop performance.
CO2	Distinguish among empirical, statistical, and dynamic crop modeling approaches and discuss their practical applications.
CO3	Utilize crop simulation models (e.g., DSSAT, InfoCrop, APSIM) to forecast crop growth, yields, and pest or disease risks.

CO4	Develop crop models covering soil, plant and environment continuum

Theory

Unit I

Principles of crop production; effect of weather elements on crop responses; impact of natural and induced variability of climate on crop production.

Unit II

Introduction and application to crop modeling, types of models, Empirical and statistical crop weather models their application with examples; concept of crop growth model in relation to weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models;

Unit III

Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc.; optimization, calibration and validation of models. Weather data and physiology- based approaches to modeling of crop growth and yield; forecasting of pests and diseases; stochastic models; advantages and limitation of modeling.

Practical

Working with statistical and simulation models, DSSAT models, InfoCrop, Oryza, etc.

Text Books

1. Wallach D *et al. Working with dynamic crop models*.
2. Hanks RJ. 1974. *Model for Predicting Plant Yield as Influenced by Water Use*. Agron. J. 66: 660-665.

Reference Books

1. DeWit CT, Brouwer R and de Vries FWTP. 1970. *The Simulation of Photosynthetic Systems*. pp. 7-70. In. Prediction and Measurement of Photosynhetic Activity. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.
2. Duncan WG. 1973. *SIMAI- A Model Simulating Growth and Yield in Corn*. In: The Application of Systems Methods to Crop Production (D.N. Baker, Ed.). Mississippi State Univ. Mississipi.
3. Frere M and Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting*. FAO.
4. Hay RKM and Porter JR. 2006. *The physiology of crop yield* (2nd Edition).
5. Keulen H Van and Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop*. Simulation Monographs. PUDOC, Wageningen.
6. Singh P. *Modelling of crop production systems: Principles and applications*.
7. WeiXing Cao *et al. Crop modeling and decision support.*

Evaluation Pattern

Internals (35%)

Mid-Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR519 - RS and GIS applications in Agricultural Meteorology 2 0 1 3

Course Overview

To impart the theoretical and practical knowledge of remote sensing principles andtheir use to estimate of agro-meteorological variables.

Course Outcome:

After learning the course, the students should be able to:

CO1	Explain the fundamental principles of remote sensing, including the characteristics of electromagnetic radiation, sensor systems, and data acquisition methods.
CO2	Interpret remote sensing imagery and digital data to analyze soil, crop, and environmental conditions.
CO3	Apply GIS and GPS technologies to support agricultural monitoring, resource mapping, and decision-making processes.
CO4	Evaluate remote sensing applications for crop discrimination, drought monitoring, soil assessment, and yield forecasting.

Theory

Unit I

Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

Unit II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

Unit III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance. Drone technology.

Unit IV

Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction.

Unit V

Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

Unit VI

Digital techniques for crop discrimination and identification; crop stress detection soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation. Use of satellite data in weather forecasting.

Unit VII

Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations
- Differentiation of different degraded soils
- Time domain reflectometry
- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

Text Books

1. Curan PJ. *Principles of Remote Sensing.* ELBS/Longman.
2. Georg Joseph 2005. *Fundamentals of Remote Sensing*. University Press (India).
3. Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.
4. Panda BC. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.
5. Patel AN and Surender Singh. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

Reference Books

1. Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. OXford Book Co.
2. Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.
3. Campbell JB. 1996. *Introduction to Remote Sensing*, 2nd ed., The Guilford Press, New York.

4. Colwell RN. (Ed.). *Manual of Remote Sensing*. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
5. Lilisand TM, Kiefer RW and Chipman JW. 2003. *Remote Sensing and Image Interpretation*, 5th ed., John Wiley & Sons, Inc., New York.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR520 - Organic Crop Production Systems 2 0 1 3

Course Overview

This course provides comprehensive knowledge and practical skills in organic farm planning, nutrient and water management, cropping systems, weed control, biofertilizer integration, and modeling of agronomic practices to achieve sustainable crop production in organic farming systems.

Course Outcome:

After learning the course, the students should be able to:

CO1	Explain the principles and strategies for conversion and management of organic farming systems.
CO2	Apply appropriate nutrient, water, and weed management techniques specific to organic production.
CO3	Analyse the effectiveness of cropping systems, biofertilizer integration, and resource use efficiency in organic farms.
CO4	Design agronomic models and crop management plans for sustainable organic crop production.

Theory

Unit I: Fundamentals of organic farm management and conversion

Salient features of organic farm management, strategies for conversion to organic, step-by-step planning, integration of contamination control measures, planning for on-farm input production and supplementary off-farm inputs, planning for rain water harvesting and water conservation approaches including efficient irrigation systems and moisture preservation techniques, visit to organic farms and study on farmer's best practices for conversion.

Unit II: Management of diversity and cropping systems

Importance of diversity, installation of diversity through plantation of utility trees, nitrogen fixing tree hedges, habitat management for friendly insects and birds and nitrogen fixing crops as intercrops. Importance of cropping systems management with long term planning, crop rotations, intercropping, multi cropping, relay cropping, multi-layered cropping.

Unit III: Nutrient management

Components of nutrient management in organic crop production, assessment of crop nutrient requirements, calculation of nutrient credits from on-farm practices and resources such as intercrops, cover crops, biomass mulching, calculating additional input requirements. Managing nutrient needs through use of organic manures, viz. FYM, compost, Vermicompost, oil cakes, in-situ and ex-situ green manuring, crop residue management, use of restricted organic nutrient sources, liquid organic manures and dung urine slurries, methods of manuring and biomass application, split application of manures, foliar feeding as replacement of top dressing, ITKs and farmers innovations in nutrient management

Unit IV: Integration of microbial and mineral inputs

Importance of bio fertilizers, types of biofertilizers, nutrient potential, methods of application, enriching manures/ composts with biofertilizers, identifying the need for use of supplementary mineral sources and their integration in nutrient management package.

Unit V: Weed management

Prevention of weeds through cropping systems management, crop geometry, stale seedbed technique, summer ploughing, soil solarisation, cover crops, mulching, flooding, biological weed management, selection of suitable physical and mechanical approaches and biological and plastic mulches.

Unit VI: Water and Irrigation Management

Soil-water relation, theories of water availability, water use efficiency management, methods of irrigation and automation in irrigation systems, irrigation scheduling in different crops.

Unit VII: Modeling of agronomic practices and nutrient management protocols for some important agricultural and horticultural crops

Identification of compatible associate and intercrops/ companion crops, placing trap crops and insectary plants in cropping geometry, making provisions for nutrient credits from biomass mulching, intercrops and green manures, making provisions for nutrient credits from microbial enrichment with microbial/ liquid manure inputs, balance nutrient requirement modeling and identification of inputs and planning for quantity and time of application.

Unit VIII: Crop growth and yield analysis

Crop growth expressions in plants, growth measurements, important growth indices and forms of growth analysis in field crops. Factors determining yield. Use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer

treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.

Unit IX: Success stories of effective crop management with optimum yields of practicing organic farmers (one in irrigated systems and one in rainfed systems)

Field visit, documentation of farming system with inputs and outputs, identification of practices important for organic systems, nutrient management practices, pest management protocols, yields and economics. Salient features for success and for further replication in crop production modeling.

Practical

- Visit to organic farms and study general nutrient management practices, documentation of farming system with inputs and outputs and crop growth analysis using crop growth analysis techniques
- Getting acquainted with different tilling methods and rain water harvesting and water conservation techniques
- Production of liquid manures and dung-urine slurries
- Production of customized composts using FYM/ Compost, mineral nutrients and biofertilizers, assessment of nutrient profiles in enriched composts
- Methods of application for biofertilizers
- Weed management practices, tools and efficacy of different approaches
- Modelling of agronomic practices for a given cropping system with use of available resources.

Text Books

1. Palaniappan, S. P. and Annadurai, K. (1999). *Organic Farming: Theory and Practice*. Scientific Publishers, Jodhpur, pp. 1–288.
2. Lampkin, N. (1990). *Organic Farming*. Farming Press Books, Ipswich, UK, pp. 1–701.
3. Sharma, A. K. (2004). *A Handbook of Organic Farming*. Agrobios (India), Jodhpur, pp. 1–627.

Reference Books

1. Kumar, S., Sharma, A. K., and Sharma, R. (2015). *Organic Agriculture for Sustainable Livelihoods*. Elsevier, Amsterdam, pp. 1–420.
2. Bhattacharyya, P. and Chakraborty, G. (2005). *Organic Farming in India*. Satish Serial Publishing House, Delhi, pp. 1–304.
3. Pimentel, D. (Ed.). (2007). *Food, Energy, and Society*. 3rd ed. CRC Press, Boca Raton, pp. 1–380.
4. Yadav, A. K., Deb, D., and Hore, D. K. (2017). *Organic Farming for Sustainable Agriculture*. New India Publishing Agency, New Delhi, pp. 1–450.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR521 - Farming Systems Suitable for Organic Management 2 0 1 3

Course Overview

This course covers concepts and practices of integrated, sustainable farming systems, including agro-ecology, enterprise integration, modeling, diversification, and ecological approaches.

Course Outcome:

After learning the course, the students should be able to:

CO1	Describe the concepts, types, and principles of integrated and sustainable farming systems.
CO2	Analyse agro-ecological practices and ecological engineering approaches for designing resilient farming systems.
CO3	Evaluate different enterprise integration models, including crop-livestock systems and secondary agriculture, for diverse agro-ecosystems.
CO4	Design region-specific, diversified farming system models using simulation tools and decision-support techniques.

Theory

Unit I: Introduction

Farming systems: Definition, importance, classification and scope, Classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises, Concept of sustainability in farming systems, role of integrated farming systems in agriculture, approaches

Unit II: Agro-ecology

Concepts and practices, Agro-ecology and the design of Sustainable Agro-ecosystems, Ecological processes to optimize in agro-ecosystems, Sustainable Agriculture: Basic Definitions and Concepts, Alternative Sustainable Farming Systems, Low external input sustainable agriculture

Unit III: Enterprises selection and Integration

Natural Farming Systems, Intentional Integrated Farming Systems, Pre-dominant farming systems in various regions, Eco-physiological approaches component selection and integration, Complementary and competitive interaction, Primary, Secondary, Complimentary and Supplementary enterprises for organic farming, livestock based systems, vertical farming, Principles and Practices of organic livestock production, Principles of organic aquaculture,

Organic fruit and vegetableproduction practices, Models of integrated farming systems for irrigated ecosystemsand rainfed ecosystems

Unit IV: Modeling of farming systems

Simulation models for intercropping, farming system design using farm design for various resource conditions, Linear programming, Multi-objective criteria decision making, Fuzzy logic analysis, Artificial Neural Network (ANN) based modeling, DSSAT, Infocrop, Cropsyst, Livesim

Unit V: Integrated Organic Farming Systems

Concepts, Principles, Strategies, Diversity plantations, Diversified cropping systems, crop rotations, soil fertility management, Selection of seeds, varieties and planting material, nutrient management, weed and pest management, integration of livestock, breeds and allied activities, In-situ recycling of Organic Wastes, Products and processes of composting, Component optimization, Market input chain, family employment generation, case studies, supplementary, Complimentary and substitution effects under dry-land, irrigated, wetland and hill-zone eco systems

Unit VI: Soil-crop-livestock-human chain

Bio-nutrition concepts, design of farming systems for nutrition, Household levelproduction of food, feed, fodder, fertilizer, fuel and fibre from farming systems

Unit VII: Secondary Agriculture

Product diversification, Process diversification, processing of marketable surplus produces, packaging, branding and marketing

Unit VIII: Contract Farming

Farming system based cluster formation, production, processing and marketing, legal aspects of contract farming

Unit IX: Specialized farming systems

Protected cultivation, high value crops based systems, water based farming systems, region specific integrated farming systems, medicinal herb based systems

Unit X: Farming System diversification

EXisting scenario of farming systems, need for diversification, methods of diversification, horizontal and vertical diversification

Unit XI: Four P Model of organic farming system

4P (Planning, Production, Processing and Promotion) model of organic farmingsystems

Unit XII: Ecological Engineering

Principles and Practices, Ecological engineering approach of soil fertility and pest management, eXamples of ecological engineering in traditional farming systems, case studies

Practical

- Agro-ecosystem analysis: Field study of farming systems in the context of production flows, energy flows and pest dynamics using quantitative tools
- Farming System typology analysis and clustering of group of farmers
- Synthesis of organic farming system model for a given region using primary and secondary data
- Estimation of ecological, economic, social and sustainable livelihood indicators for a given farming system
- Design of alternative farming systems using Farm Design and other available modelling tools
- Experiential learning on different enterprises
- Documentation of farming system case studies

Text Books

1. Palaniappan, S.P. and Annadurai, K. (1999). *Organic Farming: Theory and Practice*. Scientific Publishers, Jodhpur, India. pp. 1–265.
2. Reddy, S.R. (2016). *Farming Systems and Sustainable Agriculture*. Kalyani Publishers, Ludhiana, India. 2nd ed. pp. 1–450.
3. Panda, S.C. (2015). *Farming Systems and Sustainable Agriculture*. Agrobios (India), Jodhpur, India. pp. 1–372.
4. Singh, R.P. (2006). *Sustainable Farming Systems*. Kalyani Publishers, New Delhi, India. pp. 1–310.

Reference Books

1. Lichtfouse, E. (2018). *Sustainable Agriculture Reviews: Volume 32*. Springer, Cham, Switzerland. pp. 1–450.
2. Gliessman, S.R. (2015). *Agroecology: The Ecology of Sustainable Food Systems*. CRC Press, Boca Raton, USA. 3rd ed. pp. 1–405.
3. Pretty, J. (2008). *Sustainable Agriculture and Food*. Earthscan, London, UK. pp. 1–550.
4. Uphoff, N. (2002). *Agroecological Innovations: Increasing Food Production with Participatory Development*. Earthscan, London, UK. pp. 1–320.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR522 - Organic Certification Standards and Regulation 2 0 1 3

Course Overview

This course covers standards, certification, inspection, and traceability of organic production systems under national and international frameworks.

Course Outcome:

After learning the course, the students should be able to:

CO1	Understand national and international standards, regulations, and certification processes governing organic production systems.
CO2	Apply ISO procedures and documentation requirements to develop and implement organic certification and inspection protocols.
CO3	Analyse compliance issues in crop, livestock, and processing systems and propose appropriate contamination control and traceability measures.
CO4	Evaluate internal control systems, participatory guarantee systems, and third-party certification frameworks for effective certification management.

Theory

Unit I

National and international regulations on quality assurance and certification

National Programme for Organic Production (NPOP), National Standards for Organic Production (NSOP), USDA NOP Programme and standards, EU Organic standards, Codex Alimentarius, Canada Organic regulation and important differences between NPOP and international standards. FSS Act 2006 for organic food, basic requirements, enforcement, standard operating procedures and verification in value chain

Unit II

ISO systems for quality assurance (ISO 17065, ISO 17011, ISO 19011 etc) and accreditation processes

What is ISO, salient features and functions of ISO, ISO systems for auditing, ISO 17065 for auditing and certification agencies, ISO 19011 Inspection protocols, ISO17011 Accreditation requirements, ISO 17025 Accreditation of quality analysis laboratories. Accreditation procedure and policies under NPOP, Essential requirements and competence for making an organic certification body, Conflict of interest management

Unit III

Types of certification systems (NPOP and PGS), standards and procedures

NPOP - A third party certification systems, Certification bodies operational policies and functions, National standards for crop production, livestock, Aquaculture, Processing and handling and other miscellaneous systems. Tracenet the online data management tool and traceability management

PGS – Participatory Guarantee Systems – Evolution of PGS Systems, Guiding principles, PGS Standards, International scenario on PGS development Procedure for organic guarantee under PGS systems, PGS-India programme, operation of PGS-India programme, institutional structure, PGS-India Data management platform, management of traceability.

Unit IV

On-field management of standard compliance and documentation

Issues for implementation of standards on field such as conversion period, contamination control, fertility management, living condition requirement for livestock, management of integrity in processing and handling, Fundamental policy for inspections, step-by-step inspection protocols, Development of inspection formats and inspection checklists. Documentation requirements such as organic system plan, field operation register, input and cultural practices record, processing record, purchase and sales records and product flow in processing.

Unit V

Individual and grower group certification management

Basic requirements for certification management by (a) Individual producer and (b) Grower/ producer groups. Applicability and types of systems covered

Unit VI

Inspection (under NPOP) and peer review (under PGS) systems

Fundamental principles of inspection, checklists and inspection parameters, general policy frame work

NPOP – Third party inspection procedure, risk assessment, documentation and record keeping review, physical verification of facilities, fields and stables, production facilities, estimated yield/production assessment, tracking the product flow throughout the process, chain of custody. Review of inspection forms and checklists and certification decisions.

PGS-India – Peer review principles, making of peer review committees and peer review checklists, analysis of peer review checklists and certification decisions. Submission of summary sheets to Regional councils and assessment and endorsement of certification decisions.

Unit VII

Certification of crop, livestock, aquaculture and other systems

Standards, their implementation in production systems, measures for contamination control, integrity management, sanitation and hygiene, input evaluation procedures, development of process tracking checklists

Unit VIII

Certification of processing, handling, trading and management of traceability

Standards, their implementation in production/ processing and handling systems, measures for contamination control, integrity management, sanitation and hygiene, packaging and labelling, development of process tracking checklists

Unit IX

Internal control system management in large farmer groups under NPOP

Large farmer groups, essential requirements, internal control systems, development of ICS operating manual, management of ICS, internal inspections, risk assessment, assessment of internal inspections and certification decisions, additional documentation for groups, produce/ output management and sale record management

Unit X

PGS Group development and PGS certification management

Essential requirements for local groups, development of local group operating manuals, requirements of group meetings and trainings, decision making by farmers, operational policies for Regional Councils, developing operating manual for Regional councils, assessment of summary sheets and decisions of local groups, procedure for decision endorsement and certification granting

Practical

- Documentation of certification procedures, acquaintance with record keeping, handling, labeling and preparation of farmers IDs for developing ICS.
- Visit to certification bodies, certified farms, certified processing and handling operations
- Development of organic system plan for specific production system
- Development of inspection format and checklists for specific production system
- Development of operating procedures on specific aspects
- Risk assessment on organic farms and possible mitigating measures
- Running of audit trails in certified operations
- Mock inspections of different production systems
- Exercise on inspection report/ peer evaluation checklist review and certification decision
- Exercise on methods of yield assessment

Text Books

1. Bhattacharyya, P. and Chakraborty, G. (2005). *Organic Certification and Accreditation*. I.K. International Publishing House Pvt Ltd, New Delhi, pp. 1–320.
2. Lampkin, N. H. (1990). *Organic Farming*. Farming Press Books, Ipswich, UK, pp. 1–701.
3. IFOAM (2002). *IFOAM Norms for Organic Production and Processing*. International Federation of Organic Agriculture Movements, Bonn, Germany, pp. 1–105.
4. Willer, H. and Lernoud, J. (Eds.) (2019). *The World of Organic Agriculture: Statistics and Emerging Trends 2019*. Research Institute of Organic Agriculture (FiBL) and IFOAM – Organics International, Bonn, Germany, pp. 1–370.

Reference Books

1. Sharma, A. K. (2006). *A Handbook of Organic Farming*. Agrobios, Jodhpur, India, pp.

1–632.
2. FAO (2002). *Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods*. Food and Agriculture Organization of the United Nations (Codex Alimentarius Commission), Rome, Italy, pp. 1–92.
3. Khosla, R. (2016). *ISO 9001:2015 Quality Management Systems*. Standards Media, New Delhi, pp. 1–280.
4. Raynolds, L. T. (2004). *The Globalisation of Organic Agro-Food Networks*. World Development, 32(5):725–743.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGR523 - Organic Input Management and Production Technologies 2 0 1 3

Course Overview

To provide knowledge on various organic inputs, their production technologies, quality control and commercialization aspects

Course Outcome:

After learning the course, the students should be able to:

CO1	Identify and differentiate the types, standards, and regulatory frameworks of organic inputs used in organic farming systems.
CO2	Demonstrate knowledge of production methods and application techniques for on-farm nutrient management inputs, biofertilizers, and composts.
CO3	Analyse the production, formulation, and field application of microbial biopesticides, botanical pesticides, and beneficial insects for pest management.
CO4	Design integrated organic input management plans for sustainable crop production, including quality control and compliance with certification standards.

Theory

Unit I: Introduction

Need for on-farm and off-farm (eXternal) organic inputs, types of organic inputs allowed under organic farming, regulatory scenarios and standards. Status of organic and biological input industry in the country.

Unit II: On-farm inputs soil fertility and nutrient management

Types of on-farm inputs for soil fertility and nutrient management, their need assessment under specific cropping systems *vis-à-vis* soil test reports, methodologies for recycling of on-farm biomass and crop residue, innovative traditional inputs such as jivamrit, beejamrit, panchgavya etc. their microbial profiling and nutrient mobilization potential and standardized production methods, Oil cakes and their applications.

Unit III: On-farm inputs, plant health management and pest control

Types of plant protection inputs and intervention approaches, use of biological and ecological approaches, preventive practices, Types of plants used in plant protection and their biological characterization for pest control, basic methodologies for active ingredient eXtraction and on-farm formulations.

Unit IV: Composts and their value added products

Types of composts, their characters, nutrient potential, composting methodologies (aerobic, anaerobic, NADEP, *etc*), value added composts, quality control parameters, commercial production methodologies for city waste compost, Phosphate Rich Organic manure (PROM), bio-organic manure, technologies for product formulations such as enrichment and granulations, *etc.*

Unit V: Biofertilizers

Types of biofertilizers, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants.

Unit VI: Microbial Biopesticides

Types of biopesticides, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier based inoculants, liquid inoculants and lyophilized inoculants. Types of polyhedrosis and granulosis viruses and their production methodologies.

Unit VII: Mass rearing of beneficial insects

Introduction to beneficial insects such as pest predators and parasites, classification and identification, mass rearing technologies including rearing of host insects, Production of egg cards of beneficial insects and their release in the field.

Unit VIII: Botanical pesticides and other non-chemical pest protectants

Type of non-chemical plant protection options, importance of soaps and oils, important plants having pesticidal properties, plant parts having pesticidal active ingredient and their extraction methodologies, product formulation and stabilization for increased shelf life, field assessment of efficacy. Regulatory scenario and quality parameters.

Practical

- Getting familiarized with on-farm soil fertility management inputs (such as beejamrit, jivamrit, panchgavya etc), ingredients needed and production methodology. Preparation and quality assessment
- Application of such inputs in small plots on selected crops and observation on growth
- Production of different composts including vermicompost
- Quality analysis of composts for nutrients and heavy metals
- Biofertilizer organisms, their laboratory characterization, sub-culturing and mother culture development
- Fermentation technology demonstration, production of bacterial broth in pilot scale fermenters
- Biofertilizer product formulations and quality analysis methods
- Study biopesticide organisms, laboratory culturing, mass cultivation using solid state fermentation, liquid fermentation and spore harvesting methods and product formulations
- Visit to beneficial insect rearing laboratory and handling of insects including demonstration on tricho-cards production

- EXtraction of neem seed kernel eXtracts and neem oil. Production of botanical eXtracts and product formulation using emulsifiers
- Study effect of various botanical eXtracts on insect pests
- Preparation of BordeauX miXtures and copper fungicides

Text Books

1. Gaur, A. C. (2006). *Biofertilizers in Sustainable Agriculture*. ICAR, New Delhi, India.
2. Subba Rao, N. S. (2004). *Soil Microorganisms and Plant Growth*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.
3. Singh, A., Parmar, B. S., and Dureja, P. (2009). *Biopesticides: Use and Delivery*. Springer, Dordrecht, Netherlands.
4. Somasundaram, E. (2020). *Organic Farming: Principles and Practices*. Agrobios (India), Jodhpur.

Reference Books

1. Bhattacharyya, P., and Chakraborty, G. (2005). *Organic Farming in India: Problems and Prospects*. ICAR, New Delhi, India.
2. Panwar, J. D. S., and Singh, S. (2014). *Organic Input Production: Technologies and Business Opportunities*. National Centre of Organic Farming, Ghaziabad.
3. Kannaiyan, S., Kumar, K., and Govindarajan, K. (2004). *Biofertilizers Technology, Marketing and Usage*. Scientific Publishers, Jodhpur, India.
4. Glare, T. R., and Moran-Diez, M. E. (2016). *Microbial-Based Biopesticides: Methods and Protocols*. Humana Press, New York.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25SAC502- Soil Fertility and Fertilizer Use 2 0 1 3

Course overview

This course teaches how to manage soil fertility and use fertilizers effectively. Students will learn about essential plant nutrients, types of fertilizers, soil testing, and how to improve soil health. Practical sessions include testing soil and plant samples in the lab to support sustainable and productive agriculture.

Course outcome

After learning the course, the students should be able to:

CO1	Explore the essential plant nutrients and their role and functions in soil and plants
CO2	Understand the concepts of soil fertility and nutrient dynamics in soil and plants
CO3	Apply integrated and site-specific nutrient management techniques such as STCR, INM, SSNM, and biofertilizers to enhance fertilizer use efficiency and crop productivity
CO4	Evaluate soil fertility and soil health using tests and concepts like DRIS, critical limits, and long-term effects of fertilizers for sustainable agriculture.
CO5	Develop integrated nutrient management options suitable for different crop production systems

Course Syllabus

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers -

behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit IV

Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium, and magnesium fertilizers.

Unit V

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VI

Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

Unit VII

Fertilizer use efficiency; site-specific nutrient management; plant need-based nutrient management; integrated nutrient management; specialty fertilizers concept, need, and category. Current status of specialty fertilizers' use in soils and crops of India.

Unit VIII

Soil fertility evaluation - biological methods, soil, plant, and tissue tests; soil quality for sustainable agriculture, Determination of critical limit, DRIS

Unit IX

Definition and concepts of soil health and soil quality; long-term effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)

Text books

- Havlin JL, Beaton JD, Tisdale SL, and Nelson WL. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.

- John L. Havlin, James D. Beaton, Samuel L. Tisdale, and Werner L. Nelson. 2011. Soil Fertility and Fertilizers- An Introduction to Nutrient Management. PHL Learning Pvt. Ltd.,New Delhi
- Gupta, P. K. 2012. A Handbook of Soil, Fertilizer and Manure. Agrobios (India), Jodhpur.
- Manures and Fertilizers (2009) by P. C. Das, Kalyani Publishers, New Delhi
- Soil Fertility and Nutrient Management (2011) by S. S. Singh, Kalyani Publishers, New, Delhi

Reference books

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker.
- Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. Manures and Fertilizers. Agri-Horti Publ.
- Ramesh Chandra and S. K. Singh. 2009. Fundamental and Management of soil quality. Westville Publishing House, New Delhi.
- Das, P.C. 1999. Manures and Fertilizers, Kalyani Publishers, New Delhi.
- Epstein, E. and A.J.Bloom. 2005. Mineral Nutrition of Plants: Principles and perspectives (2^{nd} ed). Sinauer Associates, Sunderland, MA.
- Mengel, K., E.A. Kirkby, H.Kosegarten and T.Apple. 2006. Principles of Plant Nutrition, 5^{th} ed. Springer International.
- Tandon, H.LS. 1994. Fertilizer, Organic Manures, Recyclable Wastes and Biofertilizers. Fertilizer Development and Consultation Organization, New Delhi
- Yawalkar, K.S., J.P. Agarwal and S.Bokde.2008. Manures and Fertilizers. Agri - Horticultural Publishing House, Nagpur.
- Manures and Fertilizers (2002) by K. S. Yawalkar, J. P. Agarwal and S. Bokde , AgriHorticultural Publishing House, Nagpur.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25SAC509- Remote Sensing and GIS Techniques for Soil and Crop Studies 2 0 1 3

Course Overview

This course introduces the basic concepts of remote sensing and GIS in soil and crop studies. It covers sensor technologies, image interpretation, spatial variability analysis, and GIS-based solutions for agriculture, water management, and land resource planning. Practical sessions focus on using aerial and satellite data for decision-making in agriculture and environmental management.

Course outcome

After learning the course, the students should be able to:

CO1	Understand the basic principles of remote sensing, radiation interaction with matter, and GIS components.
CO2	Identify various sensor systems, image types, and processing methods used in remote sensing.
CO3	Apply remote sensing techniques in land use mapping, soil surveys, crop stress detection, and drought management.
CO4	Utilize GIS technologies for managing water resources, enhancing agricultural practices, precision farming, disaster preparedness, e-governance, and ARIS-based research.
CO5	Analyze spatial and temporal soil variability using classical and geostatistical techniques.

Course Syllabus

Theory

Unit I

Introduction and history of remote sensing; sources, propagation of radiation in the atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability about the size of sampling; classical and geo-statistical techniques of the evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, and Agricultural Research Information System (ARIS).

Practical

Familiarization with different remote sensing equipment and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of data files in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

Textbooks

- Lillesand, T. M., Kiefer, R. W., and Chipman, J. W. 2015. Remote Sensing and Image Interpretation. 7th Ed., John Wiley & Sons, New York.
- Jensen, J. R. 2007. Remote Sensing of the Environment: An Earth Resource Perspective. 2nd Ed., Pearson Education, New Delhi.
- Anji Reddy, M. 2018. Remote Sensing and Geographical Information Systems. 3rd Ed., BS Publications, Hyderabad.

Reference books

- Campbell, J. B., and Wynne, R. H. 2011. Introduction to Remote Sensing. 5th Ed., Guilford Press, New York.

- Thenkabail, P. S. (Ed.). 2021. Remote Sensing Handbook, Volume III: Agriculture, Food Security, Rangelands, Vegetation, Phenology, and Soils. CRC Press, Taylor & Francis Group.
- Reddy, Y. S. Satish Kumar, Reddy, U. V. B., and Reddy, P. V. R. M. 2022. Geo-Informatics and Nano Technology in Precision Farming. Brillion Publishing, New Delhi.
- Schowengerdt, R. A. 2006. Remote Sensing: Models and Methods for Image Processing. 3rd Ed., Academic Press, Elsevier.
- Burrough, P. A., and McDonnell, R. A. 1998. Principles of Geographical Information Systems. Oxford University Press, New York.

Evaluation pattern

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25SAC510 – Analytical techniques and Instrumental Methods in Soil and Plant Analysis 0 0 2 2

Course Overview

This practical-based course focuses on the use of various analytical techniques and instrumental methods for soil and plant analysis. To familiarize the students with commonly used instruments, their working, and preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Course outcome

After learning the course, the students should be able to:

CO1	Prepare solutions for standard curves, indicators, and standard solutions for acid-base, oxidation-reduction, and complexometric titrations.
CO2	Apply soil, water, and plant sampling techniques and learn their processing and handling for accurate analysis.

CO3	Demonstrate the use of advanced analytical instruments like UV-Vis spectrophotometry, atomic absorption, and flame photometry for nutrient analysis.
CO4	Conduct wet digestion and extraction techniques to determine the total and available essential nutrients in soil, water and plant samples.

Course Syllabus

Practical

Unit I

Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oXidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

Text books

- Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
- Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.

- Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
- Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
- Piper CE. Soil and Plant Analysis. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN. 1999. Soil Plant Water Analysis - A Methods Manual. IARI, New Delhi.
- Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
- Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman

Reference readings

- Tandon, H. L. S. (2005). Methods of analysis of soils, plants, waters, fertilizers & organic manures (2nd ed.). Fertilizer Development and Consultation Organisation.
- Kanwar, J. S., & Chopra, S. L. (1971). Analytical agricultural chemistry (4th ed.). Kalyani Publishers.
- Trivedy, R. K., & Goel, P. K. (1986). Chemical and biological methods for water pollution studies. Environmental Publications.
- Hesse, P. R. (1971). A textbook of soil chemical analysis. John Murray.
- Patel, K. P., & Soni, K. C. (1992). Methods of fertilizer analysis. Department of Agricultural Chemistry and Soil Science, Gujarat Agricultural University.

Evaluation pattern

Internal (10%)

Assignment and Continuous Evaluation -10

External (90%)

End semester practical- 90

25SAC511-Management of Problematic Soil and Water 1 0 1 2

Course Overview

To know about the soil and the different problems that occur during cultivation. How to identify the problem and what reclamation methods are required to improve the soil health.

Students learn practically about the identification of problem soil and learn different methods to improve soil fertility, that necessary to improve the yield.

Course outcome

After learning the course, the students should be able to:

CO1	Identify and classify different types of problematic soils, including saline, sodic, acidic, and alkaline soils
CO2	Understand the causes and effects of soil salinity, sodicity, acidity, and alkalinity on crop production and land use.
CO3	Apply management practices for ameliorating problematic soils, including the use of amendments and proper irrigation methods.
CO4	Develop sustainable land and water management strategies to improve the quality of problematic soils for agricultural use.
CO5	Perform soil and water analysis for diagnosing soil problems and determining the best treatment options.

Course Syllabus

Unit I

Area and distribution of problem soils–acidic, saline, sodic, and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soils salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit VI

Agronomic practices about problematic soils; cropping pattern for utilizing poor quality groundwaters.

Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na^+, K^+, Ca^{++} and Mg^{++}) in groundwater and soil samples, Determination of an ions (Cl-, SO_4-, CO_3- and HCO_3-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

Text Books

- Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.
- Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology. Utah State University
- USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.
- Adams, F.(1984). Soil Acidity and Liming. 2nd Edn, American Society of Agronomy, Madison, U.S.A.

Reference Books

- Somani, L. L. (2019). Textbook of problematic soils and their management (2nd ed.). Agrotech Publishing Academy. ISBN: 9788183214995
- Somani, L. L. (1990). Alkali soils: Their reclamation and management. Agrotech Publishing Academy. ISBN: 9788172330535
- Somani, L. L. (2009). Diagnosis and improvement of acid soils. Agrotech Publishing Academy. ISBN: 9788172335707
- Somani, L. L. (2001). Salt-affected soils and their management. Agrotech Publishing Academy. ISBN: 9788172332935

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25SAC514-Introduction to Nanotechnology 2 0 1 3

Course overview

This course introduces the basic knowledge about nanoscience, properties of nanoparticles, fundamentals of nanotechnology, and its applications in agriculture, soil science, and environmental management.

Course outcome

After learning the course, the students should be able to:

CO1	Understand the basic principles and concepts of nanotechnology, including nanomaterials, nanostructures, and nano-systems.
CO2	Identify the different types of nanomaterials and their properties.
CO3	Explore the potential applications of nanotechnology in agriculture, including soil enhancement, nutrient delivery, and pest control.
CO4	Assess the environmental, health, and safety implications of nanotechnology in agricultural and environmental applications.
CO5	Demonstrate various methods for the synthesis and characterization of nanomaterials in a laboratory setting.

Course Syllabus

Theory

Unit I

General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, an isotropy.

Unit II

Nano structures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nanowires, fullerenes (buckballs, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-

assembled organic layers, process of synthesis of nanopowders, electrode position, important nanomaterials.

Unit III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nanoparticles, investigating and manipulating materials in the nanoscale: Electron microscopy

Unit IV

Nano-biology: Interaction between biomolecules and nano-particle surface, different types of in organic materials used for the synthesis of hybrid nano-bioassemblies, application of nano- in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

Practical

- Sources of nanoparticles and their preparation by different approaches
- Electrospinning and its use in agriculture and allied sectors.
- Equipment used in Nanotechnology: its principle and uses
- Acquaintance with different equipment used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nanoparticles.
- Mode of action of ZnO nanoparticles against soil-borne diseases
- Study on the efficacy of ZnO nanoparticles as a seed treating agent on plant growthparameters.

Text books

- Roco, M. C., and Bainbridge, W. S. 2001. Nanotechnology: Societal Impacts and Policy Issues. Springer, New York.
- Bhushan, B. 2017. Springer Handbook of Nanotechnology. 3rd Ed. Springer, Berlin.
- Agarwal, S. S., and Raghavendra, A. 2012. Introduction to Nanotechnology: Basic Concepts and Applications in Agriculture. Agrobios (India), Jodhpur.
- Kumar, S., and Mehta, A. 2020. Nanotechnology in Agriculture and Food Production. Wiley-Blackwell.
- Sahu, S. K., and Gupta, S. 2017. Nanotechnology in Agriculture and Food Production: Impacts and Applications. CRC Press, Boca Raton.

Reference books

- Ratner, M. A., & Ratner, D. (2003). Nanotechnology: A gentle introduction to the next big idea. Prentice Hall.
- Poole, C. P., & Owens, F. J. (2003). Introduction to nanotechnology. John Wiley & Sons.
- Manjunatha, S. B., Biradar, D. P., & Aladakatti, Y. R. (2016). Nanotechnology in soil science and plant nutrition. Today & Tomorrow's Printers and Publishers.
- Kah, M., Kookana, R. S., Gogos, A., & Bucheli, T. D. (Eds.). (2018). Effect of manufactured nanomaterials on crop plants: A review. Environmental Science: Nano, 5(1), 1–29.
- Ghorbanpour, M., Manika, K., & Varma, R. S. (Eds.). (2020). Nano-enabled agrochemicals in agriculture: Current status and future prospects. Springer.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25CRP501- Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition 2 0 1 3

Course Overview

The aim of this course is to impart knowledge in the field of water relations and mineral nutrition and how plants acquire water and transport it under different soil water regimes and also make use of the water in an effective way to maximize use efficiency. In addition, the other aim is to impart knowledge of how plants minimize water loss under stress conditions besides educating the students of how plants make use of nutrients in a best possible way.

Course Outcome

After learning the course, the students should be able to:

CO	Course outcome
CO1	Identify the essential macronutrients and micronutrients required for plant growth.
CO2	Illustrate the various mechanisms by which plants absorb mineral nutrients from the soil.
CO3	Propose methods to mitigate water stress in plants based on principles of water relations.
CO4	Analyze experimental data related to water uptake, transpiration rates, or nutrient absorption, and draw valid conclusions.
CO5	Develop a theoretical model illustrating the interactions between water uptake and nutrient absorption.

Course Syllabus

Theory

Block 1: Plant Water Relations

Unit I: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils;

Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit II: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit III: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution;

Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit IV: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit V: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit I: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toXicity symptoms in plants.

Unit II: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; Xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root eXudates and PGPRs in plant nutrient acquisition.

Unit III: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

Practical

- Standard solutions and preparation of different forms of solutions
- Studies on the basic properties of water
- Demonstration of surface tension of water and other solvents
- Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
- Determination of soil moisture content and soil water potential
- Use of soil moisture probes and soil moisture sensors
- Measurement of transpiration rate in plants; use of porometry
- Measurement of CCATD and its relevance
- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toXicity symptoms of nutrients

- Effect of water stress on plant growth and development

Text books

1. Taiz T, Zeiger E and Max Miller IM, 2018, Fundamentals of Plant Physiology.
2. Taiz L and Zeiger E. 2015. Plant Physiology and development.6th Ed.
3. Salisbury FB and Ross C. 1992 (4th Ed.) Plant Physiology.
4. Emanuel Epstein and Arnold J. Bloom.2004, Mineral nutrition of plants: principles and perspectives.2nd Ed.
5. Hopkins WG and Huner NPA. 2004. Introduction to Plant Physiology.
6. Kramer, P. J., Water relations of plants.

Reference books

1. Horst Marschner. 2012. Mineral Nutrition of Higher Plants.
2. Paul J. Kramer & John S. Boyer. 1995. Plant–Water Relations
3. Taiz T, Zeiger E and Max Miller IM. 2022. Plant Physiology and Development

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25CRP504- Physiological and Molecular Responses of Plants to Abiotic Stresses 2 0 1 3

Course Overview

This course aims to describe students the abiotic-stress physiology and their effects on plant growth and productivity. This will also help students gain insights into latest developments in stress physiology and stress tolerance mechanisms, approaches for crop improvement under stressful environment.

Course Outcome

After learning the course, the students should be able to:

CO	Course outcome
CO1	Design novel experimental approaches to investigate complex physiological and molecular responses of plants to various abiotic stresses
CO2	Appraise the significance and translational potential of research findings in improving crop resilience by understanding plant adaptation in a changing climate.
CO3	Identify key regulatory genes, proteins, and metabolites that serve as crucial nodes in plant stress response networks.
CO4	Apply molecular techniques to improve abiotic stress tolerance in plants
CO5	Develop suitable mitigation strategies for plants under abiotic stress

Course Syllabus

Theory

Block 1: Abiotic Stresses

Unit I: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India- Frequency of occurrence of drought, Rainfed- kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

Block 2: Drought Stress

Unit I: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum. Physiological and biochemical processes affected by drought. Oxidative stress-generation of ROS and other cytotoxic compounds, their effect on cellular process. Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit II: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception and signal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

Unit III: Plant Adaptive Mechanisms to Drought

Escape and desiccation avoidance mechanism Concept of stress escape- exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation-

Regulation of transpiration- traits reducing heat load, Stomatal factors guard cell metabolism, moisture conservation by waXes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model. Desiccation tolerance-Concept of acquired tolerance. Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoXic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photo-protection of chlorophylls.

Unit IV: Approaches to Improve Drought Tolerance

Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.

Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress

Unit I: Salt Stress

Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salt tolerance mechanisms - eXclusion, eXtrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance.

Unit II: Heavy Metal Stress and Water Logging

Heavy metal toXicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

Unit III: Temperature and Light Stress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oXidation and photo- inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR).

Practical

- Measurement of soil and plant water status.
- Drought stress imposition and measurement of physiological and biochemical changes in plants under stress –gas eXchange and fluorescence measurements.
- Determination of water use efficiency as a drought resistant trait.
- Drought Susceptibility IndeX (DSI) -precise field technique to identify productive genotypes under stress.
- Approaches to quantify root characters
- Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity.
- Determination of Salinity Tolerance IndeX.
- Studying acclimation response - Temperature induction response.

- Heat tolerance and membrane integrity- Sullivans heat tolerance test.
- Quantification of osmolytes – proline under stress.
- OXidative stress imposition- Quantification of oXidative stress
- Quantification of ROS under stress.
- Estimation of ABA content in leaf and root tissues under stress.
- Determination of Sodium and Potassium in plant tissue grown under salt stress.
- Estimation of antioXidant enzymes.

Text books

1. Khalid Rehman Hakeem, Tariq Aftab 2022. Plant Abiotic Stress Physiology (Vol. 1 & 2)
2. Emanuel Epstein and Arnold J. Bloom.2004, Mineral nutrition of plants: principles and perspectives.2nd Ed.
3. Kramer, P. J., Water relations of plants.
4. Sergey Shabala. 2017. Plant Stress Physiology

Reference books

1. Arun Shanker, B. and Venkateswarlu. 2011. Abiotic Stress in Plants – Mechanisms and Adaptations
2. Ashwani Pareek, S.K. Sopory, Hans J. Bohnert, Govindjee 2010, Abiotic Stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation
3. Mirza Hasanuzzaman, Kamrun Nahar. 2024. Abiotic Stress in Crop Plants – Ecophysiological Responses and Molecular Approaches

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25CRP507- Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling 2 0 1 3

Course Overview

The course provides a comprehensive theoretical and hands on experience and expertise to students on various aspects of photosynthesis including biophysical, biochemical and molecular regulations. While canopy photosynthesis drives crop growth rates, factors associated with sink activity and partitioning determine productivity. Hence, adequate emphasis would be given to canopy photosynthesis, translocation and its feedback regulation, Crop growth and yield structure analysis and their responses to

environmental factors. Growth and yield prediction models and their relevance will be adequately discussed.

Course Outcome

After learning the course, the students should be able to:

CO	Course outcome
CO1	Understand the biochemical and biophysical principles governing photosynthesis in C3, C4, and CAM plants, including photoprotective mechanisms.
CO2	Critically appraise the strengths, weaknesses, and applicability of various existing crop growth models (e.g., mechanistic, empirical, or hybrid models) for different crops and environments.
CO3	Interpret model outputs and sensitivity analyses to identify key parameters influencing crop growth and productivity predictions.
CO4	Utilize specialized software and programming languages (e.g., R, Python, MATLAB) to implement, run, and calibrate existing crop models or develop new model components
CO5	Design crop models for yield prediction, climate adaptation, and decision support in precision agriculture.

Course Syllabus

Theory

Block 1: Photosynthetic Processes

Unit I: Canopy Architecture and Energy Utilization

Parameters associated with canopy architecture that determine radiation interception and absorption, Energy absorption by primary and accessory pigments and energy utilization efficiency, Light distribution inside the canopy and concepts of light extinction coefficient.

Unit II: Photochemical Processes

Ultrastructure of chloroplast: structure and composition of lamellar system, Components of electron transport, Water oxidation system and energy conservation processes, Pigment systems and the generation of a powerful oxidant and a powerful reductant, Chlorophyll fluorescence and fluorescence quenching: qN, qP, NPQ.

Unit III: Biochemical Processes

CO_2 diffusion and resistances (g_s and g_m). Concept of Ci determining CO_2 diffusion. RuBisCO activation state, kinetics and catalytic properties, Carboxylation processesin C_3, C_4 and CAM plants and their relevance, CO_2 concentrating mechanisms and their importance in improving carbon assimilation, Ecological significance of C_4 and CAM photosynthesis, Photorespiration and Mitochondrial respiration and net carbon gain, Carbon isotope discrimination and its importance as a surrogate of Ci.

Unit IV: Product Synthesis and Translocation

Triose phosphate utilization and regulation of Calvin cycle mechanisms, Product synthesis and partitioning between starch and sucrose, Concepts of end-product inhibition or Pi-regeneration limitation, Phloem transport and factors that regulate phloem loading and un-loading.

Unit V: Growth and Yield forming Mechanisms

Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI andLAD in determining total carbon gain and crop growth rates, Source: Sink relationship and its relevance in governing differences in crop growth rates and productivity. Concepts of HI and partitioning coefficient and remobilization of carbon from vegetative organs to reproductive structures, Growth analysis and parametersthat explain growth rates: NAR, CGR, HI and their inter-dependence.

Block 2: Yield Improvement and Modelling

Unit I: Molecular Options to Improve Photosynthesis, Growth and Productivity

Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities. Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR etc), Theoretical concepts of crop improvement through inducing CCM in C_3 plants and reducing photorespiration.

Unit II: Fundamentals of Dynamic Simulation Models

Collection of crop specific genetic coefficient, Crop, soil and historic weather data

Unit III: Description of Well-established Yield Models

Application and limitations of modeling, Yield prediction models such as APSYM, Peanut Grow etc, Machine learning approaches and IoT for making informed on- farm decisions.

Unit IV: Examples of Robust Models Extensively Used

Duncan's yield prediction model, Passioura's model for growth maximising.

Practical

- Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
- Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized.
- Gas exchange: principles and uses to assess variations in CO_2 and water vapour transfer, determination of A/gs and intrinsic WUE
- Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN
- Chlorophyll fluorescence and quenching coefficients
- Theoretical aspects of carbon isotope fractional and its use in determining WUE
- Quantification of RuBisCO content by ELISA
- Determination of RuBisCO activity and activation state using radioactive CO_2
- CO_2 and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
- Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models

Text books

1. Taiz T, Zeiger E and Max Miller IM, 2018, Fundamentals of Plant Physiology.
2. Govindjee. 2012. Photosynthesis V2: Development, Carbon Metabolism, and Plant Productivity
3. Afshin Soltani, Thomas Sinclair. 2012. Modeling Physiology of Crop Development, Growth and Yield.

Reference books

1. Richard C. Leegood, Thomas D. Sharkey, Susanne von Caemmerer.2000. Photosynthesis: Physiology and Metabolism
2. Robert Sharwood. 2023. Understanding and Improving Crop Photosynthesis
3. Kenneth J. Boote. 2019. Advances in Crop Modelling for a Sustainable Agriculture

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25CRP512- Crop Growth Regulation and Management 2 0 0 2

Course Overview

Provides comprehensive information on light regulation in polyhouse cultivation, photoperiod responses by red/far red light for synchronizing flowering, techniques for pollen biology and hybrid production, chemical regulation of plant growth processes like flower initiation, flower drop, fruit maturity, ripening and shelf-life, etc.

Course Outcome

After learning the course, the students should be able to:

CO	Course outcome
CO1	Understand the physiological mechanisms of crop establishment involved in different methods of crop propagation.
CO2	Differentiate the roles of various hormones and signaling molecules in controlling specific developmental processes
CO3	Interpret various interventions to regulate various physiological processes and growth.
CO4	Design novel management strategies and protocols that integrate physiological principles, environmental conditions, and technological advancements to optimize crop growth, yield, and quality under specific agro-climatic zones.

Course Syllabus

Theory

Block 1: Propagation - Crop Establishment

Unit I: Seed as a Propagule

Concept of improving seed characteristics for crop establishment. Mechanisms of regulating seed dormancy, precocious germination, ways to control pre-harvest sprouting in crop plants. Seed viability and its regulation, factors to minimize loss of viability and improve seedling vigour. Concept of seed priming, techniques of priming, seed priming to induce tolerance to stresses. Role of media, nutrition and PGPR's on seedling vigour and subsequent crop establishment.

Unit II: Vegetative Propagule

Chemical and hormonal regulation of vegetative propagation. Regulation of rooting, bud sprouting, Bulb/tuber dormancy. Chemical regulation of graft union. Concept of *in vitro* micropropogation.

Block 2: Regulation of Plant Growth Processes

Unit I: Regulation of Plant Growth and Flowering

Chemical and hormonal regulation of plant architecture, tillering, branching, bud breaking, Regulation of flowering by photo and thermoperiod, nutrients, chemicals and hormones, concept of speed breeding, Flowering synchrony in hybrid seed production, Sex ratio alteration, flower and fruit thinning, Pollen viability in relation to environment, harvesting, storage and transportation, Prevention of abscission, flower and fruit drop, seed and fruit growth regulation- role of hormones.

Unit II: Fruit Ripening and its Regulation

Approaches to improve shelf life – storage environment, water loss, respiration, Modified atmosphere, gaseous environment for storage, storage disorders, chilling injury.

Unit III: Concept of Senescence and its Retardation

Physiology of senescence and options to regulate, Chemical regulation of senescence, maintenance of chlorophyll during storage, role of hormones/micronutrients inreducing senescence, Concept of stay green, advantages and limitations. Relevance of stay green traits in plant breeding for crop improvement.

Block 3: Protective Cultivation–Stress Mitigation

Unit I: Protective Cultivation Interventions to Alter Physiological Processesand Growth

Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic and photomorphogenic processes and plant growth, LED sources of monochromatic light to regulate growth, etiolating and flowering, High temperature induced thermomorphogenic processes, Artificial growing media, soilless cultures, aeroponics, fogoponics, Concept of CO_2 fertilization. Effect of humidity on leaf expansion and growth.

Unit II: Drought Mitigation Options and Approaches

Moisture conservation options at soil and plant level, Concept of increasing water holding capacity, role of Hydrogels – water and mineral nutrients release pattern. Approaches to improve transpiration over evapo-transpiration, stomatal and non- stomatal regulation of water loss, antitranspirants, Osmoprotectants, ROS scavengers, plant nutrients, Root stocks in improving tolerance, Chemical regulationof flower drop due to temperature, Chemicals to improve pollen viability during abiotic stress.

Unit III: Specific Plant Processes Regulated by Chemicals and Growth Hormones

Rooting of cuttings, Wine brewing industry, Promotion of gynoecious flower, Hybrid rice production, Induction of flowering in pine apple, cucurbits, Delaying of senescence and ripening, Production of dwarf plant for ornamental purpose,Reduction in flower and fruit drop, Increase in berry size in grapes.

Text books

1. Amarjit Basra, 2024, Plant Growth Regulators in Agriculture and Horticulture.
2. S.N. Ghosh, R.K. Tarai, T.R. Ahlawat 2022. Plant Growth Regulators in Tropical and Sub-tropical Fruit Crops
3. Mahesh Chand Singh, K.K. Sharma. 2024. Protected Cultivation: Structural Design, Crop Management Modeling, and Automation
4. Anukool Vaishnav, S.S. Arya, D.K. Choudhary. 2022. Plant Stress Mitigators: Action and Application.

Reference books

1. Golam Jalal Ahammed, Jie Zhou. 2025. Growth Regulation and Quality Improvement of Vegetable Crops.
2. Vishal Singh Rana, Neerja Rana, Sunny Sharma. 2025. Advances in Growth Regulation of Fruit Crops.

3. M. Naeem, Tariq Aftab. 2021. Emerging Plant Growth Regulators in Agriculture: Roles in Stress Tolerance

Evaluation Pattern

Internals (50%)

Mid Semester Theory – 40

Assignment and Continuous Evaluation 10

Externals (50%)

End Semester Theory– 50

25AGM505- Soil Microbiology 2 0 1 3

Course Overview

To provide an overview of soil microorganisms, help unlock and harness the potential of microorganisms in improving soil fertility and crop production.

Course Outcome:

After learning the course, the students should be able to:

CO1	Define different types of soil microorganisms, their habitat, diversity and factors governing their activity.
CO2	Relate the role of beneficial microorganisms in improving soil fertility and crop production
CO3	Explain the role of beneficial microorganisms in stress amelioration, plant immunity, soil health and decomposition of xenobiotics
CO4	Demonstrate the role of soil microorganisms in improving the soil fertility and crop production

Course Syllabus

Theory

Block 1: Developments in Soil Microbiology and Soil Parameters

Unit I: Historical prospective of soil microbiology. Factors affecting soilmicroflora.

Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microflora as pH, chemicals, moisture, air, temperature etc.

Unit II: Ecology of soil microbiology

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

Block 2: Microbiology and Biochemistry of Plant Parts

Unit I: Plant parts and soil interface interaction

Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance.

Block 3: Role of Microorganisms in Nutrient Biocycle

Unit I: Microbial transformation of various nutrients

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganesein soil. Siderophores and antimicrobials.

Unit II: Microbial degradation of organic matter

Biochemical composition and biodegradation of soil organic matter and crop residues.

Unit III: Microbial diversity

Endophytic microorganisms Mycorrhizae, types and role in phosphate mobilization. Potassium releasing bacterium. Microbes in biotic and abiotic stress management.

Unit IV: Role of microorganisms in biodegradation of xenobiotics and pesticides

Biodegradation of pesticides, Organic wastes and their use for production of biogasand manures: Biotic factors in soil development.

Practical

- Determination of soil microbial population
- Determination of Soil microbial biomass
- Decomposition studies in soil, Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification
- N_2 fiXation, S oXidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect
- Microbial diversity Endophytic microorganisms
- Mycorrhizae, types and role in phosphate mobilization Potassium releasing bacterium
- Microbes in biotic and abiotic stress management

Text Books:

1. Paul , E . A. 2014. Soil Microbiology, Ecology and Biochemistry. 4th Ed., Academic Press, USA

2.Subba Rao, N. S. 1999. Soil Microorganisms and plant Growth. Oxford and IBH, New Delhi

3. Robert L Tate III 2020- Soil Microbiology, Third Edition,, Willey Black well

Reference Books:

1. Alexander, M. 1977. Soil Microbiology. John Wiley and Sons. New York

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25AGM511- Biofertilizer Technology 2 0 1 3

Course Overview

To familiarize the students and farmers with mass scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.

Course Outcome:

After learning the course, the students should be able to:

CO1	Define Agriculturally important microorganisms, Plant growth promoting microbes, Biocontrol microbes for soil health
CO2	Relate the role of biofertilizers, PGPRs and Biocontrol agents in plant health
CO3	Explain mode of action of beneficial microorganisms biocontrol organisms in maintaining the plant health
CO4	Demonstrate the mass production aspects of biofertilizers and bio pesticides

Theory

Block 1: Agriculturally Important Beneficial Microorganisms

Unit I: Agriculturally important beneficial nitrogen fixing microorganisms.

Different agriculturally important beneficial microorganisms: Chemical Vs Biofertilizers: Current Scenario in biofertilizer technology in world-In India-List of biofertilizers-their applications in agriculture. Brief introduction about Agriculturally beneficial microorganisms (free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including phosphobacteria, cyanobacteria, their types and importance, taxonomic classification, Nitrogen fixing biofertilizers: nodule formation, competitiveness and quantification of N_2 fixed and their use. BIS standards of biofertilizers

Unit II: Agriculturally important beneficial microorganisms related to phosphorous, potassium, Sulphur and Zinc nutrition

Different agriculturally important beneficial microorganisms: phosphate solubilizing bacteria and fungi, including mycorrhiza; Mechanism of phosphorous solubilization by phosphobacteria. Bacteria for potassium, Sulphur and Zinc nutrition.

Unit III: Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria.

Different agriculturally important beneficial microorganisms: plant growth promoting rhizobacteria. FCO norms and biofertilizer production and usage at national and international levels

Unit IV: Agriculturally important biocontrol microbial inoculants

Different agriculturally important beneficial microorganisms: Biocontrol microbial inoculants. Requirements for establishing bioinoculants production unit. Economics of biofertilizers production Constraints in biofertilizers production and usage

Unit V: Economics of biofertilizer production

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

Block 2: Production of Biofertilizer

Unit I: Production and quality control of biofertilizer

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio inoculants. Biofertilizer inoculation and microbial communities in the soil. Different formulations of biofertilizers. Advantages and limitations of Liquid formulations.

Practical

- Isolation of phosphate solubilizing microorganisms.
- Development and production of efficient microorganisms,
- Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fiXing activity, indole acetic acid (IAA), siderophore production etc,
- Bioinoculant production and quality control.
- Population dynamics in broth and carrier materials during storage.
- Development of cultures from starter.
- Preparation of broth for large scale cultivation in fermenter/ large containers. Inoculation and development of culture.
- Mass production of carrier based and liquid biofertilizers. Mass production of important two or three biocontrolagents (*Trichoderma viride, Pseudomonas fluorescens* and *Metarhizium anisopliae*).
- Form, dose and method of application.
- Mass production of AM fungi in pot and root organ culture.
- Quality control and BIS standards.
- Mass production of Azolla and BGA.
- Visit to a biofertilizer production plant

Text Books:

1. The Complete Technology Book on Biofertilizer and Organic Farming by Dr. Himadri Panda (NIIR Project Consultancy Services)
2. Biofertilizers Technology by S. Kannaiyan, K. Kumar, and K. Govindarajan (Scientific Publishers)
3. Biofertilizers Technology by Dr. Singh Tanuja and Dr. Purohit S.S. (Agrobios (India)
4. Biofertilizer Technology by Kurra Venkata Gopaiah (Random Publications)

Reference Books:

1. Bio fertilizer Manual (FNCA - Forum of Nuclear Cooperation in Asia)
2. Manufacture Of Biofertilizer and Organic Farming by H. Panda (NIIR Project Consultancy Services)
3. Biopesticides Handbook (2nd Edition) edited by Leo M.L. Nollet and Showkat Rasool Mir (CRC Press/Routledge)
4. Biopesticides: Botanicals and Microorganisms for Improving Agriculture and Human Health edited by Timothy O. Adejumo and Ralf T. Vögele (Logos Verlag Berlin GmbH)
5. Biopesticides for Sustainable Agriculture edited by Nick Birch and Travis Glare (Burleigh Dodds Science Publishing)
6. Organic Farming - Biocontrol and Biopesticide Technology by Dr. P. Bhattacharyya & Dr. S.S. Purohit (Agrobios (India) / Jain Book Agency)
7. Biopesticides manual: guidelines for selecting, sourcing and using biocontrol agents for key pests of tobacco by K. Holmes et al. (CABI Books)

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25GPB502-Principles of Plant Breeding 2 0 1 3

Course Overview

To impart theoretical knowledge and practical skills on plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Course Outcome:

After learning the course, the students should be able to:

CO1	Define and explain the core concepts of plant breeding
CO2	Describe the different modes of reproduction in plants
CO3	Explain the genetic basis of plant breeding
CO4	Conduct breeding procedures that can lead to elite breeding lines of major crops

Course Syllabus

Theory

Unit I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

Unit II

Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

- Floral biology in self and cross pollinated species;
- Selfing and crossing techniques;
- Selection methods in segregating populations and evaluation of breeding material;
- Analysis of variance (ANOVA);
- Estimation of heritability and genetic advance;
- Maintenance of experimental records;
- Learning techniques in hybrid seed production using male-sterility in field crops;
- Prediction of performance of double cross hybrid.

Text Books:

1. Principles of Plant Breeding by B.D. Singh

2. Principles of Plant Genetics and Breeding by George Acquaah
3. Fundamentals of Plant Breeding by Phundan Singh
4. Plant Breeding: Principles and Methods by P.K. Gupta

Reference Books:

1. Plant Breeding: Theory and Practice by N. Singh and S.S. Gill
2. Quantitative Genetics in Plant Breeding by Russel Lande, Bruce Walsh, and Michael Lynch

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

Research Methodology

25RM501- Research and Publication Ethics 2 0 0 2

Course Overview

This course introduces the philosophy and ethics of scientific research and publication, covering scientific misconduct, publication ethics, open access publishing, research metrics, and tools for maintaining integrity and transparency in scholarly work.

Course Outcome:

After learning the course, the students should be able to:

CO1	Understand the fundamental concepts of philosophy, ethics, and moral philosophy as they apply to science and research.
CO2	Identify various forms of scientific misconduct, including falsification, fabrication, plagiarism, and unethical publication practices.
CO3	Apply standard guidelines and tools (e.g., COPE, plagiarism detection software) to ensure research integrity and ethical publication.
CO4	Evaluate research metrics and indexing databases to assess the quality and impact of scientific journals and publications.

Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Definition, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME, etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing (selecting correct and predatory journals): open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify predatory publications developed by SPPU,

Journal finder/journal suggestions tools viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools. Training on reference management software like End Note

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, Scopus, etc. Impact factor of journal as per journal citation report, SNIP,SJR, IPP, Cite Score; Metrics: h-index, g-index, i10-index altmetrics.

Text Books

1. Shamoo, A. E. and Resnik, D. B. (2015). *Responsible Conduct of Research.* 3rd ed. Oxford University Press, New York.
2. Steneck, N. H. (2007). *Introduction to the Responsible Conduct of Research.* Office of Research Integrity, U.S. Department of Health and Human Services, Washington D.C.
3. Macrina, F. L. (2014). *Scientific Integrity: Text and Cases in Responsible Conduct of Research.* 4th ed. ASM Press, Washington D.C.
4. Committee on Publication Ethics (COPE). (2011). *Code of Conduct and Best Practice Guidelines for Journal Editors.* COPE, London.

Reference Books

1. Kumar, P. and Choudhury, P. L. (2017). *Ethics in Science Education, Research and Governance*. Indian National Science Academy (INSA), New Delhi.
2. Saxena, A. (2019). *Scientific Research Methodology and Ethics*. Alpha Science International, Oxford.
3. World Association of Medical Editors (WAME). (2015). *Publication Ethics Policies for Medical Journals.* WAME, Philadelphia.
4. Bennett, D. M. and Taylor, D. M. (2003). *Unethical Practices in Authors and Editors: A Review.* Medical Journal of Australia.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25RM502- Mathematics for Applied Sciences 2 0 0 2

Course Overview

To provide foundational mathematical knowledge for students with limited background and covers linear algebra, differentiation, integration, and differential equations to prepare for advanced studies.

Course Outcome:

After learning the course, the students should be able to:

CO1	Understand and apply basic set theory concepts, set operations, and functions relevant to mathematical reasoning and problem-solving
CO2	Demonstrate the ability to perform vector and matrix operations, including calculation of eigenvalues, eigenvectors, and solving systems of linear equations using determinants
CO3	Analyze the behavior of functions using limits, continuity and derivatives and apply differentiation techniques to solve real-world problems including optimization
CO4	Apply integration techniques and solve differential equations with a focus on practical applications in agriculture and related disciplines

Course Syllabus

Theory

Unit I

Set Theory-set operations, finite and infinite sets, operations of set, function.

Unit II

Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solutions of Linear Equations.

Unit III

Variables and functions, limits and continuity of specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

Unit IV

Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration and Differential Equations in Agriculture

Text Books

1. Hohn F E. 2013. Elementary Matrix Algebra, 3rd Ed., Kindle Edition
2. Stewart J. 2007. Calculus. Thompson.
3. Thomas G.B. Jr. and Finney R.L. 1996. Calculus. 9th Ed. Pearson Edu.

Reference Books

1. Harville D.A. 1997. Matrix Algebra from a Statistician's Perspective. Springer.
2. Hohn F.E. 1973. Elementary Matrix Algebra. Macmillan.
3. Searle S.R. 1982. Matrix Algebra Useful for Statistics. John Wiley.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25RM503- Statistical Methods for Applied Sciences 3 0 1 4

Course Overview

To provide a foundational understanding of statistical methods and inference and to discuss data presentation, probability distributions, parameter estimation, significance tests, regression and multivariate analysis.

Course Outcome:

After learning the course, the students should be able to:

CO1	Understand of core statistical principles, including probability theory, sampling distributions, hypothesis testing, confidence intervals, and power analysis.
CO2	Apply a wide range of advanced statistical techniques (e.g., generalized linear models, time series analysis, survival analysis, mixed-effects models, non-parametric methods, Bayesian statistics) to real-world datasets from various scientific disciplines.
CO3	Analyze complex datasets using advanced statistical software, identifying patterns, relationships, and significant differences within and across variables.
CO4	Apply a wide range of advanced statistical techniques (e.g., generalized linear models, time series analysis, survival analysis, mixed-effects models, non-parametric methods, Bayesian statistics) to real-world datasets from various scientific disciplines.
CO5	Design novel statistical models and methodologies to address complex, multi-variate research questions in their specific applied science fields, going beyond standard textbook approaches

Course Syllabus

Theory

Unit I

Box-plot, Descriptive statistics, exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

Unit II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

Unit III

Introduction to Theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model,

test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

- Exploratory data analysis, fitting of distributions ~Binomial, Poisson, Negative Binomial, Normal.
- Large sample tests, testing of hypothesis based on exact sampling distributions ~chi square, t and F.
- Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

Text Books

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. 1983. Fundamentals of Statistics. Vol. I. The World Press
2. Anderson, T. W. 2009. An Introduction to Multivariate Statistical Analysis, 3rd Ed . John Wiley

Reference Books

1. Goon, A.M, Gupta, M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
2. Hoel, P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
3. Hogg, R.V. and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
4. Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
5. Hogg, R. V, McKean J. W, Craig, A. T. 2012. Introduction to Mathematical Statistics 7th Edition.
6. Siegel S., Johan, N. & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
7. http://freestatistics.altervista.org/en/learning.php.
8. http://www.statsoft.com/textbook/stathome.html

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25RM504- Experimental Designs 2 0 1 3

Course Overview

To introduce the concepts of experimental design, focusing on planning, structuring and analyzing experiments effectively, and to equip learners with the skills needed to design experiments and interpret experimental data in scientific research.

Course Outcome:

After learning the course, the students should be able to :

CO1	Understand the fundamental principles of randomization, replication, and local control, and their importance in establishing cause-and-effect relationships.
CO2	Apply advanced statistical software (e.g., R, SAS, SPSS, Python) to implement and analyze data from various experimental designs, including factorial, split-plot, and nested designs.
CO3	Differentiate between various types of experimental error and implement strategies (e.g., replication, blocking, covariance analysis) to reduce or account for them.
CO4	Evaluate the appropriateness, strengths, and limitations of various experimental designs (e.g., CRD, RCBD, Latin Square, Factorial, Split-Plot, Repeated Measures) for different research questions, considering statistical power, practical feasibility, and ethical implications.
CO5	Develop innovative data collection protocols and measurement strategies that align with the chosen experimental design to capture relevant variables with high precision and accuracy.

Course Syllabus

Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
- Analysis with missing data,
- Split plot and strip plot designs.

Text Books

1. Cochran, W. G and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
2. Dean, A. M and Voss, D. 1999. Design and Analysis of Experiments. Spinger.

Reference Books

1. Montgomery, D. C. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.
2. Federer, W. T. 1985. Experimental Designs. MacMillan.
3. Fisher, R. A. 1953. Design and Analysis of Experiments. Oliver & Boyd.
4. Nigam, A. K. and Gupta, V. K. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
5. Pearce, S. C. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. www.drs.icar.gov.in

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25RM505- Basic Sampling Techniques 2 0 1 3

Course Overview

To introduce elementary sampling techniques to support planning and designing of surveys, and analysis and presentation of survey data. To highlight the relevance of the techniques for applications in the social sciences.

Course Outcome:

After learning the course, the students should be able to :

CO1	Understand the principles of probability sampling versus non-probability sampling.
CO2	Apply computational tools and software (e.g., R, Python, SAS, Excel) to draw random samples, calculate sample sizes, and analyze data obtained from various basic sampling designs
CO3	Analyze the mathematical foundations of probability and non-probability sampling techniques, including calculations of sampling error, confidence intervals, and required sample sizes.

CO4	Develop simulation scenarios to assess the performance and efficiency of different basic sampling designs under varying population characteristics and research objectives
CO5	Formulate original solutions to overcome practical challenges in implementing sampling techniques in real-world research settings, such as incomplete sampling frames or non-response bias.

Course Syllabus

Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

Text Books

1. Cochran, W. G. 1977. Sampling Techniques. John Wiley.

Reference Books

1. Murthy, M. N. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.
2. Singh, D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.
3. Sukhatme, P. V, Sukhatme, B. V., Sukhatme, S. and Asok, C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
4. Cochran, W. G. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25RM506 - Applied Regression Analysis 2 0 1 3

Course Overview

To introduce the concepts of correlation and regression with emphasis on diagnostic measures like autocorrelation, multicollinearity, and heteroscedasticity and to analyze and interpret data effectively

Course Outcome:

After learning the course, the students should be able to :

CO1	Understand the theoretical underlying of various regression models, including ordinary least squares (OLS), generalized linear models (GLMs), mixed-effects models, and potentially time series regression or non-linear regression.
CO2	Apply a wide range of advanced regression techniques using professional statistical software packages (e.g., R, Python with statsmodels/scikit-learn, SAS, Stata, SPSS) to real-world datasets.
CO3	Analyze complex datasets using various regression techniques, correctly interpreting coefficients, p-values, confidence intervals, and measures of model fit.
CO4	Critically appraise the assumptions, strengths, and limitations of various regression models (e.g., OLS, GLM, Mixed Models, Time Series Regression, Non-linear Regression) for specific datasets and research contexts.
CO5	Develop custom analysis pipelines using statistical software to implement advanced regression techniques and visualize their results effectively for diverse audiences.

Course Syllabus

Theory

Unit I

Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

Unit III

Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

Unit IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection;
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Text Books

1. Kleinbaum, D. G, Kupper LL, Nizam A. 2007. Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.

Reference Books

1. Draper, N. R. and Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
2. Ezekiel, M. 1963. Methods of Correlation and Regression Analysis. John Wiley.
3. Koutsoyiannis, A. 1978. Theory of Econometrics. MacMillan.
4. Kutner, M. H., Nachtsheim CJ and Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student C. D. McGraw Hill.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25RM507 - Data Analysis using Statistical Packages 2 0 1 3

Course Overview

To provide hands-on experience in using various statistical software packages for data analysis and to support the research data analysis across all disciplines

Course Outcome:

After learning the course, the students should be able to :

CO1	Understand statistical tests and models are implemented computationally within statistical packages.
CO2	Apply a wide range of statistical analysis techniques using at least one advanced statistical package (e.g., R, Python etc.,).
CO3	Analyze complex datasets using various statistical procedures within software packages, accurately interpreting the numerical and graphical outputs.

CO4	Critically evaluate the appropriateness and limitations of different statistical packages
CO5	Develop custom scripts and functions within statistical software environments to automate repetitive tasks, perform specialized analyses, or generate tailored visualizations

Course Syllabus

Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, *t* and *F* statistics and Z-test.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

Text Books

1. Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
2. Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley.
3. Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
4. Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall

Reference Books

1. Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.
2. Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995.
3. Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
4. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
5. Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
6. Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.
7. Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
8. Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire Conn.
9. Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
10. Weisberg S. 1985. Applied Linear Regression. John Wiley.
11. Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
12. Wetherill GB.1986. Regression Analysis with Applications. Chapman & Hall.
13. Cleveland WS. 1994. The Elements of Graphing Data, 2nd Ed., Chapman & Hall http://freestatistics.altervista.org/en/learning.php.
14. http://freestatistics.altervista.org/en/stat.php.
15. http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
16. http://www.stat.sc.edu/~grego/courses/stat706/. www.drs.icar.gov.in.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25MCA501 - Computers Fundamentals and Programming 2 0 1 3

Course Overview

This course aims at exposingthe students to understand how computer works, analytical skills to solve problems using computers and to write computer programs using C.

Course Outcome

After learning the course, the students should be able to :

CO1	Understand the basic components of a computer system, number systems, and data representation formats such as ASCII and Unicode.

CO2	Develop algorithms and flowcharts and translate them into C programs using appropriate data types, expressions, and control structures.
CO3	Analyse arrays, structures, pointers, and dynamic memory allocation in C programs to solve computational problems.
CO4	Evaluate program logic for correctness, perform debugging, and apply techniques to test and validate C programs effectively.

Theory

Unit I

Functional units of computer, I/O devices, primary and secondary memories. Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, Operator precedence, character representation; ASCII, Unicode.

Unit II

Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Constants and variables; Data types: integer, character, real, data types; Arithmetic expressions, assignment statements, logical expressions. Control flow

Unit III

Arrays and structures. Pointers, dynamic memory allocations

Unit IV

Program Structures – functions, subroutines

Unit V

I/O operations, Program correctness; Debugging and testing of programs.

Practical

- Conversion of different number types;
- Creation of flow chart, conversion of algorithm/flowchart to program;
- Mathematical operators, operator precedence;
- Sequence, control and iteration;
- Arrays and string processing;
- Matrix operations, Sorting, Pointers and File processing – Reading and writing text files.

Text Books

1. Balagurusamy, E. (2020). *Programming in ANSI C*. 8th ed. McGraw Hill Education,

New Delhi, pp. 1–580.
2. Rajaraman, V. (2018). *Computer Fundamentals*. 6th ed. Prentice-Hall of India, New Delhi, pp. 1–350.
3. Gottfried, B. S. (2017). *Programming with C*. 3rd ed. McGraw Hill Education, New Delhi, pp. 1–450.
4. Yashavant Kanetkar. (2021). *Let Us C*. 17th ed. BPB Publications, New Delhi, pp. 1–480.

Reference Books

1. Kerninghan, B. W. and Ritchie, D. M. (1988). *The C Programming Language*. 2nd ed. Prentice Hall, New Jersey, pp. 1–272.
2. Gill, N. S. (2017). *Handbook of Computer Fundamentals*. 3rd ed. Khanna Publishers, New Delhi, pp. 1–600.
3. Venugopal, K. R. and Prasad, S. R. (2007). *Mastering C*. McGraw Hill Education, New Delhi, pp. 1–750.
4. Forouzan, B. A. (2013). *Computer Science: A Structured Programming Approach Using C*. 3rd ed. Cengage Learning, Boston, pp. 1–800.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25MCA502 - Computer Organization and Architecture 2 0 0 2

Course Overview

This is a course on Computer Organization and Architecture that aims at exposing the students to understand basic knowledge of how computer works.

Course Outcome

After learning the course, the students should be able to :

CO1	Explain the concepts of number systems, Boolean algebra, and the design of combinational and sequential circuits.
CO2	Analyse the functional organization of CPU operations, instruction cycles, and pipelining processes.
CO3	Differentiate various memory organizations and storage technologies including cache, RAID, and DRAM.
CO4	Assess input-output mechanisms, microprocessor architectures (CISC and RISC), and their role in computer system performance.

Theory

Unit I

Number systems; Boolean algebra - minimization of Boolean function using Karnaugh Map.

Unit II

Logic Gates, Combinational circuits – multiplexer, de-multiplexer, encoder, decoder; Sequential circuits: Flip-flops, Half and Full adder, Shift register, Counters.

Unit III

Organization of CPU, Control Unit- Instruction and Execution cycle in CPU, Register Organization, The Instruction Cycle, Instruction Pipelining.

Unit IV

Memory organization - Internal memory: Semiconductor Main Memory (RAM, ROM, EPROM), Cache Memory, Advanced DRAM Organization; Magnetic Disks, RAID, Optical Memory, Magnetic Tape.

Unit V

Basic structure of computer hardware and system software - Addressing methods and machine programme sequencing; Input-output organizations - accessing I/O devices - direct memory access (DMA) – interrupts.

Unit VI

Introduction to microprocessors – CISC and RISC Architecture, Study of functionalunits of microprocessors.

Text Books

1. Mano, M. M. (2017). *Digital Logic and Computer Design*. Pearson Education, New Delhi.
2. Stallings, W. (2019). *Computer Organization and Architecture: Designing for Performance* (11th ed.). Pearson, New Delhi.
3. Patterson, D. A., and Hennessy, J. L. (2017). *Computer Organization and Design: The Hardware/Software Interface* (5th ed.). Morgan Kaufmann Publishers, San Francisco.
4. Hayes, J. P. (2012). *Computer Architecture and Organization*. McGraw-Hill, New Delhi.

Reference Books

1. Hamacher, C., Vranesic, Z., and Zaky, S. (2012). *Computer Organization* (5th ed.). McGraw-Hill, New Delhi.
2. Morris, M. (2016). *Fundamentals of Digital Logic with VHDL Design* (3rd ed.). McGraw-Hill Education, New Delhi.
3. Heuring, V. P., and Jordan, H. F. (2017). *Computer Systems Design and Architecture* (2nd ed.). Pearson, New Delhi.
4. Tanenbaum, A. S., and Austin, T. (2013). *Structured Computer Organization* (6th ed.). Pearson, New Delhi.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25MCA503 - Introduction to Communication Technologies, Computer Networking and Internet 1 0 1 2

Course Overview

This is a course on Introduction to Networking and Internet Applications that aims to expose the students to understand Computer networking and web applications development.

Course Outcome

After learning the course, the students should be able to :

CO1	Understand fundamental concepts of data communication
CO2	Explain the functions of different network layers
CO3	Understand Internet principles and technologies
CO4	Apply basic networking concepts to real-world scenarios

Theory

Unit I

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP), Internet Protocol v4 & v6. Network infrastructure and Security-switches, routers, firewall, intranet, internet, Virtual Private Network

Unit II

World Wide Web (www), working with Internet; Web pages, web sites, web servers; Web Applications.

Unit III

Hyper Text Markup Language (HTML), DHTML, web-based application development. Static websites, dynamic websites. Client Side processing – scripting languages, Jquery. Server Side processing ASP.NET/JSP

Practical

- Network and mail configuration;
- Using Network Services;
- Browsing of Internet;

- Creation of web pages;
- Creation of websites using HTML and scripting languages.

Text Books

1. Forouzan, B. A. (2013). *Data Communications and Networking*. 5th ed. McGraw Hill Education, New Delhi.
2. Tanenbaum, A. S., and Wetherall, D. J. (2010). *Computer Networks*. 5th ed. Pearson Education, New Delhi.
3. Kogent Learning Solutions Inc. (2008). *Web Technologies: HTML, JavaScript, PHP, Java, JSP, ASP.NET, XML and Ajax, Black Book*. Dreamtech Press, New Delhi.
4. Stallings, W. (2013). *Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud*. Pearson Education, New Delhi.

Reference Books

1. Comer, D. E. (2018). *Internetworking with TCP/IP – Principles, Protocols and Architecture*. 6th ed. Pearson Education, New Delhi.
2. Powell, T. A. (2010). *HTML & CSS: The Complete Reference*. 5th ed. McGraw Hill Education, New Delhi.
3. Achyut S. Godbole and Kahate, A. (2008). *Web Technologies: TCP/IP to Internet Application Architectures*. Tata McGraw-Hill, New Delhi.
4. Kurose, J. F., and Ross, K. W. (2017). *Computer Networking: A Top-Down Approach*. 7th ed. Pearson Education, New Delhi.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25MCA504 - Information Technology in Agriculture 2 0 0 2

Course Overview

This is a course on Introduction to Networking and Internet Applications that aims at exposing the students to understand analogy of computer, basic knowledge of MS Office. Also to understand Internet and WWW, use of IT application and different IT tools in Agriculture

Course Outcome

After learning the course, the students should be able to:

CO1	Comprehend the role and significance of IT in modern agriculture
CO2	Understand the principles and applications of Precision Agriculture/Smart Farming
CO3	Apply IoT concepts to agricultural scenarios

CO4	Develop basic data analytical frameworks utilizing AI and Machine Learning approaches in agriculture

Theory

Unit I

Introduction to Computers, Anatomy of computer, Operating Systems, definition and types, Applications of MS Office for document creation & Editing, Data presentation, interpretation and graph creation, statistical analysis, mathematical eXpressions,

Unit II

Database, concepts and types, uses of DBMS in Agriculture, World Wide Web (WWW): Concepts and components, Introduction to computer programming languages, concepts and standard input/output operations. e-Agriculture, concepts and applications,

Unit III

Use of ICT in Agriculture, Computer Models for understanding plant processes. IT application for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone Apps in Agriculture for farm advises, market price, postharvest management etc.,

Unit IV

Geospatial technology for generating valuable agri-information. Decision support systems, concepts, components and applications in Agriculture, Agriculture EXpert System, Soil Information Systems etc. for supporting Farm decisions, Preparation of contingent crop-planning using IT tools

Text books

1. Rao, N. H., and Sarma, P. B. S. (2010). *Agricultural Informatics: An Introduction*. BSP Books Pvt. Ltd., Hyderabad.
2. Balasubramanian, P., and Thamilarasi, K. (2016). *Information and Communication Technology for Agriculture*. New India Publishing Agency, New Delhi.
3. Gautam, A., and Kumar, A. (2018). *ICT Applications in Agriculture*. Agrotech Publishing Academy, Udaipur.
4. Singh, G., Kaur, P., and Singh, A. (2019). *Fundamentals of Computer Applications in Agriculture*. Kalyani Publishers, Ludhiana.

Reference Books

1. Somasundaram, S., and Reddy, K. S. (2011). *Geoinformatics Applications in Agriculture*. New India Publishing Agency, New Delhi.

2. Aggarwal, R. K., and Agarwal, D. K. (2012). *Computers and Their Applications to Agriculture*. Jain Brothers, New Delhi.
3. Shamshad, S. (2013). *Geospatial Technologies for Natural Resources Management*. New India Publishing Agency, New Delhi.
4. Alex, K. (2010). *Fundamentals of Information Technology*. Vikas Publishing House, New Delhi.

Evaluation Pattern

Internals (50%)

Mid Semester Theory– 40

Assignment and Continuous Evaluation – 10

Externals (50%)

End Semester Theory – 50

25BIC505- Basic Biochemistry 3 0 1 4

Course Overview

The course is designed to provide elementary knowledge/overview of structure and function of proteins, carbohydrates, lipids, nucleic acids and other biomolecules and their metabolism.

Course Outcome:

After successful completion of this course, students will be able to:

CO1	Understand the scope, importance, and principles of biochemistry
CO2	Explain the structure, classification, and functions of biomolecules, plant secondary metabolites, and molecules involved in metabolism.
CO3	Summarize the metabolic pathways, molecules involved in metabolism and bioenergetics processes underlying catabolism and ATP production.
CO4	Outline the fundamentals of molecular biology and recombinant DNA methods.
CO4	Apply the analytical techniques to quantitatively and qualitatively estimate different biomolecules.

Theory

Block 1: Introduction to Biochemistry

Unit I: Scope and importance of biochemistry (1 Lecture)

Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit II: Foundation of life (2 Lectures)

Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit III: Water (3 Lectures)

Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit IV: Physical techniques for structure determination (2 Lectures) General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure and Function of Biomolecules

Unit I: Biomolecules (10 Lectures)

Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit II: Immunoglobulins and PR proteins (2 Lectures)

Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit III: Plant secondary metabolites (3 Lectures)

Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit I: Molecules aiding metabolism (2 Lectures)

Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal and plants.

Unit II: Thermodynamics –principles and energetic of life (2 Lectures) Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit I: Catabolism of energy molecules (5 Lectures)

Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit II: ATP formation (3 Lectures)

Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic Theory and proton motive force.

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit I: Molecular biology processes (4 Lectures)

Overview of replication, transcription and translation.

Unit II: Recombinant DNA technology (3 Lectures)

Restriction enzymes, DNA cloning, applications of cloning, transgenics.

Practical

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- EXtraction and estimation of sugars
- EXtraction and estimation of amino acids
- EXtraction and estimation of proteins
- Estimation of acid value of fat/oil
- Estimation of peroXide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods
- Estimation of Ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity
- Qualitative tests for secondary plant metabolites.

Text Books

1. Lehninger, A.L., Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th ed. W.H. Freeman and Company, New York, pp. 1–1300.
2. Berg, J.M., Tymoczko, J.L., Gatto, G.J. and Stryer, L. (2019). *Biochemistry*. 9th ed. W.H. Freeman and Company, New York, pp. 1–1200.
3. Voet, D. and Voet, J.G. (2011). *Biochemistry*. 4th ed. John Wiley & Sons, New York, pp. 1–1428.
4. Jain, J.L., Jain, S. and Jain, N. (2016). *Fundamentals of Biochemistry*. 7th ed. S. Chand Publishing, New Delhi, pp. 1–1150.

Reference Books

1. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Weil, P.A. (2018). *Harper's Illustrated Biochemistry*. 31st ed. McGraw-Hill Education, New York, pp. 1–800.
2. Satyanarayana, U. (2017). *Biochemistry*. 5th ed. Elsevier, New Delhi, pp. 1–800.
3. Gupta, P.K. (2018). *Elements of Biotechnology*. 4th ed. Rastogi Publications, Meerut, pp. 1–450.
4. Nelson, D.L. and Cox, M.M. (2013). *Lehninger Principles of Biochemistry Companion Handbook*. W.H. Freeman and Company, New York, pp. 1–400.

Evaluation Pattern

Internals (35%)

Mid Semester Theory – 30

Assignment– 5

Externals (65%)

End Semester Practical - 15

End Semester Theory– 50

25BIC506 - Techniques in biochemistry 2 0 2 4

Course Overview

To provide hands-on experience to different biochemical techniques commonly used in research along with the knowledge on principles and the instrumentation.

Course Outcome:

After successful completion of this course, students will be able to

CO1	Apply the techniques for separation of biomolecules using chromatography, electrophoresis, and centrifugation methods.
CO2	Explain the different spectroscopic techniques to analyze biomolecules
CO3	Explain the principles and applications of microscopy
CO4	Utilize PCR and ELISA techniques in biomolecule analysis

Theory

Block 1: Separation Techniques

Principles and applications of separation techniques.

Unit I: Chromatography techniques (4 Lectures)

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column & HPTLC, GC, HPLC and FPLC.

Unit II: Electrophoretic technique (2 Lectures)

General principles, paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Unit III: Hydrodynamic methods (2 Lectures)

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit IV: Centrifugation (2 Lectures)

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit I: Spectrophotometry (3 Lectures)

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit II: Mass spectroscopy (3 Lectures)

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit III: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit I: Microscopic techniques (2 Lectures)

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit I: Tracer technique (2 Lectures)

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of á, â and ã emitters, scintillation counters, J-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit II: Imaging techniques (2 Lectures)

Principles and applications of phosphor imager, MRI and CT scan.

Unit III: Immunochemical technique (2 Lectures)

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.

Unit IV: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

Practical

- Expression of concentration in terms of dilution, molarity, normality, percent expression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- $(NH_4)_2SO_4$ precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA (Western blotting/ Dot blotting)

Text Books

1. Plummer, D.T. (1988). *An Introduction to Practical Biochemistry*. 3rd ed. Tata McGraw-Hill Publishing Company, New Delhi.
2. Wilson, K. and Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. 7th ed. Cambridge University Press, Cambridge.

3. Boyer, R.F. (2000). *Modern Experimental Biochemistry*. 3rd ed. Addison Wesley Longman, San Francisco.
4. Ninfa, A.J., Ballou, D.P. and Benore, M. (2010). *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. 2nd ed. Wiley, Hoboken.

Reference Books

1. Freifelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. 2nd ed. W.H. Freeman and Company, New York.
2. Skoog, D.A., Holler, F.J. and Crouch, S.R. (2017). *Principles of Instrumental Analysis*. 7th ed. Cengage Learning, Boston.
3. Meyers, R.A. (Ed.). (1997). *Molecular Biology and Biotechnology: A Comprehensive Desk Reference*. Wiley-VCH, New York.
4. Sambrook, J. and Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual*. 3rd ed. Cold Spring Harbor Laboratory Press, New York.

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