PG Degree Programme Syllabus as per BSMA, ICAR

M.Sc. (Agri.) Soil Science

M.S. Swaminathan School of Agriculture

Centurion University of Technology and Management

Alluri Nagar, P.O. - R Sitapur, Via- Uppalada, Paralakhemundi, Dist: Gajapati – 761211, Odisha, India

2025

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PREAMBLE

Soils comprise a multiple phase system consisting of numerous solid phases (about 50%), a liquid phase (about 25%) and a gas phase (about 25%). The solids include rock consisting of many different primary and secondary minerals. Superimposed on this inorganic matrix is what Truog (1951) described as the 'living phase' which includes bacteria, fungi, actinomycetes, algae, protozoa, nematodes and other forms of life. These living organisms are continuously breaking down organic residues and synthesizing many of the products into body tissues while others are released to the surroundings Many physical, chemical and biological changes continually take place in soils. Physical processes such as wetting, drying, freezing, thawing changing temperatures and leaching modify the surface areas of soil particles. Primary minerals change to secondary minerals as ionic species in solution seek lower free energy levels. In addition, plants capture energy from sun and store in the form of organic compounds. Because of dynamic nature of soils, various changes take place regularly in soils and therefore, it is very essential to know the behaviour of soil solution, matrix potential so that proper technology can be achieved through research works.

Our knowledge has increased rapidly during the last decade concerning the role of macro and micro nutrients in soils, plants, animal nutrition and in food for man. The skills of several scientific disciplines, combined with sophisticated instruments, have extended our knowledge about nutrients in plants and soils to molecular level and to microenvironments of roots in soil. One of the cherished objectives of the salient feature of the revised syllabi is to foster high standard in education system of soil science. A paradigm shift is necessary in education prioritization to meet the challenges of the present and future in soil science. Students, therefore have to be acquainted with the modern concepts of different processes, concepts and development so as to develop competencies on the area of specialization of the subject. For the purpose, it is proposed to revise the course syllabus of Soil Science in the light of the present days need incorporating the basic concepts, developments of the discipline. The existing M.Sc. (Agri.) courses of soil science have been modified taking into account of present day need by incorporating the necessary and important topics in the respective courses such as basic principle of physics applied to soils, fertility status of major soil groups of India, Long term effect of manures and fertilizers on soil fertility and crop productivity, Soil health quality in relation to human health, Speciality fertilizers, Concept of quantity intensity relationship, Soil mapping, Interaction of clay with humus, pesticides and heavy metals, Soil enzyme, Humus formation, Root rhizosphere and Biodegradation of pesticide.

The new topics are covered in the courses as Soil-plant-atmospheric continuum (SPAC), Kinetics studies of nutrients in soils, Climate change on soil properties and Carbon sequestration. Major changes have been made in some of the existing courses like soil fertility and fertilizer uses, soil biology and biochemistry and Analytical technique and instrumental methods in soil and plant analysis under M.Sc. programme and Biochemistry of soil organic matter under programme. As a part of course curriculum, M.Sc. (Agri.) soil science was restructured to equip students to tackle emerging issues by inclusion of two new courses on (i) Soil survey and land use planning (ii) Introduction to nanotechnology.

The courses of soil science was revised by adding four important new courses (i) Recent trend in soil microbial diversity (ii) Soil resource management (iii) Clay mineralogy (iv) Modelling of soil plant system

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CONTENT

Framework of the courses

The following nomenclature and Credit hours need to be followed while providing the syllabus for all the disciplines

Course Title	M.Sc. (Agri.)
I. Major courses	
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
II.Thesis	30
Total	**70**

M.Sc. (Agri.) Soil Science

Couse Code	Course title	Credit hours	Page no.
MAJOR COURSE			
*SOIL 0501	Soil physics	2+1	07
*SOIL 0502	Soil fertility and fertilizer use	2+1	09
*SOIL 0503	Soil chemistry	2+1	11
*SOIL 0504	Soil mineralogy, genesis and classification	2+1	13
SOIL 0505	Soil erosion and conservation	2+1	14
SOIL 0506	Soil Biology and Biochemistry	2+1	16
SOIL 0507	Radioisotopes in soil and plant studies	1+1	17
SOIL 0508	Soil, water and air pollution	2+1	19
SOIL 0509	Remote sensing and GIS technique for soil and crop studies	2+1	20
SOIL 0510	Analytical technique and instrumental methods in soil and plant analysis	0+2	22
SOIL 0511	Management of problematic soils and water	1+1	23
SOIL 0512	Land Degradation and Restoration	1+0	25
SOIL 0513	Soil Survey and Land use Planning	2+0	26
SOIL 0514	Introduction to nanotechnology	2+1	27
SOIL 0591	Master's Seminar	1+0	
SOIL 0599	Master's research	30	
MINOR COURSE			
AGRO 0504	Principles and practices of water management	2+1	29
AGRO 0511	Cropping system for sustainable agriculture	2+0	31
AGRO 0512	Dryland Farming and Watershed Management	2+1	32
PGPP 0501	Principles of Plant Physiology I- Plant Water Relations and Mineral Nutrition	2+1	34
PGPP 0505	Hormonal Regulation of Plant Growth and Development	2+1	36
SUPPORTING COURSE			
STAT 0502	Statistical methods for applied sciences	3+1	40
STAT 0511	Experimental designs	2+1	41
STAT 5012	Basic Sampling Techniques	2+1	43
STAT 0522	Data Analysis Using Statistical Packages	2+1	44
COMMON COURSE			
PGSS 0501	Library and information services	1+0	46
PGSS 0502	Technical writing and communications Skills	1+0	46
PGSS0503	Intellectual property and its management in agriculture	1+0	48
PGSS0504	Basic concepts in laboratory techniques	1+0	49
PGSS0505	Agricultural research, research ethics and rural Development programmes	1+0	50

***** Compulsory courses

Course wise contents and books for references/resources for M.Sc. (Agri.) Soil Science

MAJOR COURSE

Course No.: SOIL 0501
Credit hours: 2+1
Course title: Soil Physics

Objectives:

1. To impart knowledge on the basic principles of soil physics and its importance in agriculture.
2. To study the various physical properties of soil.
3. To know the different types soils physical processes in relation to plant growth.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;
CO1: The students will be familiar with different types of soil structure and texture.
CO2: The students will learn different soil water potentials and soil water energy concepts.
CO3: The students will gain understanding of different aspects of soil air and soil temperature.
CO4: The students will get acquainted with various physical constraints of soil and its management.
CO5: The students will pursue principles of soil physics applicable to different types of soils.

	PSO-1	PSO-2	PSO-3
CO1	✔		✔
CO2	✔		
CO3	✔		
CO4		✔	
CO5		✔	

Theory
UNIT I: Basic principles of physics applied to soils, soil as a three phase system.

UNIT II: Soil texture, textural classes, mechanical analysis, specific surface.

UNIT III: Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

UNIT IV: Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -

mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT V: Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT VI: Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT VII: Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

UNIT VIII: Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

UNIT IX: Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

Determination of Bulk Density, Particle Density and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method, Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Suggested Readings

Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley and Sons.
Ghildyal BP and Tripathi RP. 2001. Soil Physics. New Age International.
Hanks JR and Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
Hillel D. 1980. Applications of Soil Physics. Academic Press.
Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.
Hillel D. 1998. Environmental Soil Physics. Academic Press.
Kohnke H. 1968. *Soil Physics*. McGraw Hill.
Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Course No.: SOIL 0502
Credit hours: 2+1
Course title: Soil Fertility and Fertilizer Use

Objectives:

1. To learn about different types of fertilizers and their application methods to increase fertilizer use efficiency.
2. To study the chemistry of various plant nutrients in soil and their role in crop production.
3. To know about different soil fertility evaluation methods and soil fertility management practices.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will familiarize with different types of fertilizers, its nutrient contents and chemistry in soil.

CO2: The students will get knowledge of role and functions of various plant nutrients in crop production.

CO3: The students will learn different aspects of soil fertility evaluation and soil fertility management.

CO4: The students will get acquainted with different soil and plant testing techniques and able to suggest fertilizer doses to crops.

CO5: The students will gain an understanding of soil health and soil quality along with the long-term effects of fertilizers on soil quality.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3	✔	✔	
CO4			✔
CO5	✔		

Theory

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 V : 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 VI: 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 VII: Common soil test methods for fertilizer recommendations; quantity- intensity relationships; soil test crop response correlations and response functions.

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

UNIT IX: Soil fertility evaluation- biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS.

UNIT X: 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)

Suggested Readings

Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.

Course No.: SOIL 0503
Credit hours: 2+1
Course title: Soil Chemistry

Objective:

1. To know the classical concepts of soil chemistry.
2. To impart knowledge on the modern developments in chemistry of soils.
3. To study the various soil chemical phenomenon in relation to nutrient supply.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will get acquainted with different soil chemical and physico-chemical phenomena.

CO2: The students will gain knowledge of soil colloids, its characteristics and interaction with organic matter.

CO3: The students will learn different classical theories of ion exchange and its importance in nutrient supply.

CO4: The students will understand various chemical constraints of soil and its management.

CO5: The students will become proficient with the chemistry of problematic soils, geochemistry of micronutrients and environmental chemistry.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3	✔		✔
CO4		✔	
CO5	✔	✔	

Theory

UNIT I: Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

UNIT II: Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

UNIT III : Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface-charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay- organic interactions.

UNIT IV : Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange-

inner sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V: Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; Concep to quantity/intensity (Q/I) relationship; step and constant-rate K; management aspects.

UNIT VI: Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

UNIT VII: Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

UNIT VIII: Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

Practical

Preparation of saturation extract, measurement of pH, EC, CO_3, HCO_3, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero- charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Δ (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Suggested Readings

Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier. Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley and Sons.
Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley and Sons.
McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.
Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ.
Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.
Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

Course No.: SOIL 0504
Credit hours: 2+1
Course title: Soil Mineralogy, Genesis, Classification and Survey

Objectives:

1. To get acquainted with the various soil clay minerals and different aspects of soil taxonomy.
2. To learn soil genesis and factors affecting processes of soil formation.
3. To get knowledge on soil survey and interpret soil survey reports in terms of land use planning.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will gain deep knowledge of basic structure of alumino-silicate minerals and properties of clay minerals.

CO2: The students will understand soil genesis in terms of factors and processes of soil formation.

CO3: The students will get acquainted with different soil survey techniques and interpretation of soil survey reports for land use planning.

CO4: The students will learn different soil classification and various aspects of soil taxonomy.

CO5: The students will familiarize with different landforms and various approaches for managing soils and landscapes in the framework of agro-ecosystem.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3	✔	✔	
CO4	✔		
CO5		✔	

Theory

UNIT I: Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

UNIT II: Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

UNIT III: Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

UNIT IV: Concept of soil individual; soil classification systems- historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps- usefulness.

Practical

Separation of sand, silt and clay fraction from soil, Determination of specific surface area and CEC of clay, Identification and quantification of minerals in soil fractions, Morphological properties of soil profile in different land forms, Classification of soils using soil taxonomy, Calculation of weathering indices and its application in soil formation, Grouping soils using available database in terms of soil quality.

Suggested Readings

Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.
Dixon JB and Weed SB. 1989. *Minerals in Soil Environments*. 2nd Ed. Soil Science Society of America, Madison.
Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.
Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi
USDA. 1999. *Soil Taxonomy*. Hand Book No**.** 436. 2nd Ed. USDA NRCS, Washington.
Wade FA and Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
Wilding LP and Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*. Elsevier.
Wilding NE and Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I.

Course No : SOIL 0505

Credit hours: 2+1

Course title: Soil Erosion and Conservation

Objectives:

1. To learn the different process and factors responsible for soil erosion.
2. Identify the human activities that affects the soil erosion.
3. To know the methods of soil conservation.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO-1: Knowledge on causes and forms of soil erosion, classification of gullies and its control measures.

CO-2: Estimation of soil loss using soil loss equation and learning on crop management, and conservation practices.

CO-3: Distinguish various types of wind erosion along with its mitigation measures.

CO-4: Overall idea about various agronomic practices of soil conservation.

CO-5: Equipped with various engineering measures of soil conservation and the design of soil conversation structures.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3	✔	✔	
CO4	✔		
CO5		✔	

Theory

UNIT I: History, distribution, identification and description of soil erosion problems in India.

UNIT II: Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity- estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

UNIT III: Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

UNIT IV: Principles of erosion control; erosion control measures- agronomical and engineering; erosion control structures- their design and layout.

UNIT V: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT VI: Watershed management- concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement.

Practical

Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index, Computation of kinetic energy of falling rain drops, Computation of rainfall erosivity index (EI30) using rain gauge data Land capability classification of a watershed, Visits to a watershed.

Suggested Readings

Biswas TD and Narayanasamy G. (Eds.) 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17.

Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. Manual of Soil and Water

Conservation Practices. Oxford and IBH.
Hudson N. 1995. Soil Conservation. Iowa State Univ. Press.
Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Couse code: SOIL 0506
Credit hours: 2+1
Course title: Soil Biology and Biochemistry

Objectives:

1. To teach students the basics of soil biology and biochemistry
2. To know different biogeochemical cycles in soils.
3. To study plant growth promoting rhizobacteria and microbial interactions to improve soil health and soil fertility.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Students will get knowledge on Soil biota, soil microbial ecology and types of organisms in different soils.

CO2: Student can understand various Biological indicators of soil quality and bioremediation of contaminated soils.

CO3: Students will learn preparation and preservation methods of farmyard manure, animal manures, rural and urban composts and vermicompost.

CO4: Student will gain knowledge of Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil and biochemical composition and biodegradation of soil organic matter.

CO5: Student will know about Biofertilizers, method of production, FCO specifications and quality control.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔	✔	
CO3		✔	
CO4	✔		✔
CO5	✔	✔	

Theory

UNIT I: Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II: Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Root rhizosphere and PGPR.

UNIT III: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in

soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV: Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V: Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI: Biofertilizers – definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

UNIT VII: Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis – important mechanisms and controlling factors; soil genomics and bioprospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

Determination of soil microbial population, Soil microbial biomass, Elemental composition, fractionation of organic matter and functional groups, Decomposition of organic matter in soil, Soil enzymes, Measurement of important soil microbial processes such as ammonification, nitrification, N-fixation, S-oxidation, P-solubilization and mineralization of other micro nutrients.

Suggested Readings

Paul EA and Clark FE. *Soil Microbiology and Biochemistry.*
Lynch JM. *Soil Biotechnology*
Willey JM, Linda M. Sherwood and Woolverton CJ. *Prescott's Microbiology.*
Subba Rao NS. *Advances In Agricultural Microbiology*

Course No: SOIL 0507
Credit hours: 1+1
Course Title: Radioisotopes in Soil and Plant Studies
Objectives:

1. To teach students the basics of radio isotopes and its properties.
2. To know different applications in plant research.
3. To train students in the use of radio isotopes in soil.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Students will get knowledge on radio isotopes-properties, interaction of nuclear radiations with matter and artificial radioactivity.

CO2: Student will understand various isotopic dilution techniques used in soil and plant research.

CO3: Students will learn principles and use of radiation monitoring instruments.

CO4: Student will gain knowledge on application of isotopes in studies on organic matter,

nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency and carbon dating.

CO5: Student will know about radiation safety aspects, regulatory aspects, collection, storage and disposal of radioactive wastes.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2		✔	
CO3	✔	✔	
CO4	✔		✔
CO5	✔		

Theory

UNIT I: Atomic structure, radio activity and units; radio isotopes- properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

UNIT II: Principles and use of radiation monitoring instruments- proportional, Geiger Muller counter, solid and liquids cintillation counters; neutron moisture meter, mass spectrometry, autoradiography.

UNIT III: Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating.

UNIT IV: Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes.

Practical

Storage and handling of radioactive materials, Determination of half-life and decay constant, Preparation of soil and plant samples for radioactive measurements, Settingup of experiment on fertilizer use efficiency and cation exchange equilibria, using radio isotopes. Determination of A, E and L values of soil using 32P/65Zn. Use of neutron probe for moisture determination. Sample preparation and measurement of 15N enrichment by mass spectro-photometery/ emission spectrometry.

Suggested Reading

Comer CL. 1955. Radioisotopes in Biology and Agriculture: Principles and Practice. Tata McGraw Hill.

Glasstone S. 1967. Source Book on Atomic Energy. East West Press.

Michael FL and Annunziata. 2003. Handbook of Radioactivity Analysis. Academic Press.

Course No.: SOIL 0508
Credit hours: 2+1
Course Title: Soil, Water and Air Pollution

Objectives:

1. To know different soil, water and air pollution and its association with crop production.
2. To study nature and various sources of pollutants and its effect on soil, water and air.
3. To learn the different reclamation and management methods of soil, water and air pollution.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Student will familiar with problems of soil, water and air pollution associated with crop production.

CO2: Student will get acquainted with nature and various sources of pollutants and its effect on plants, animals and human beings.

CO3: Student will be proficient with analysis of various parameters of sewage and industrial effluents and its effect on soil.

CO4: Student will gain deep understanding of different pesticides and toxic elements and its behaviour in soil and water.

CO5: Student will gain knowledge on amelioration of contaminated soil and water and use of remote sensing in monitoring and management of soil and water pollution.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3			✔
CO4	✔		
CO5	✔	✔	

Theory

UNIT I: Soil, water and air pollution problems associated with agriculture, nature and extent.

UNIT II: Nature and sources of pollutants- agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

UNIT III: Sewage and industrial effluents- their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV: Pesticides- their classification, behaviour in soil and effect on soil microorganisms.

UNIT V: Toxic elements–their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

UNIT VI: Pollution of water resources due to leaching of nutrients and pesticides from soil;

emission of greenhouse gases- carbon dioxide, methane and nitrous oxide.

UNIT VII: Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

Suggested Reading

Lal R, Kimble J, Levine E and Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.

Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. Agro-Industries. John Wiley Interscience.

Ross SM. Toxic Metals in Soil Plant Systems. John Wiley and Sons.

Vesilund PA and Pierce 1983. Environmental Pollution and Control. Ann Arbor Science

Course No.: SOIL 0509

Credit hours: 2+1

Course title: Remote sensing and GIS Technique for Soil, Water and Crop Studies

Objectives:

1. To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries.
2. To study the application of remote sensing in general and with special reference to soil, plants and yield forecasting.
3. To know the geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will familiarize history of remote sensing; sources, propagation of radiations in atmosphere, interactions with matter and basic concepts and principles**.**

CO2: The students will get knowledge fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging, image processing and interpretations.

CO3: The students will learn remote sensing techniques-landuse soil surveys, crop stress & yield forecasting, watershed & drought management, waste land identification.

CO4: The students will get knowledge of spatial and temporal variability in soil and classical and geo-statistical techniques of evolution of soil variability.

CO5: The students will apply GIS for water resources, agriculture, precision farming, disaster management, e-governance and Agricultural Research Information System.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔	✔	✔
CO3		✔	✔
CO4	✔		
CO5		✔	✔

Theory

UNIT I: Introduction and history of remote sensing; sources, propagation of Radiations in 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 radiometer sand 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 inrelat ion to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

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

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of and 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.

Suggested Readings

Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
Elangovan K. 2006. GIS Fundamentals, Applications and Implementations. New India Publ.
Lillesand TM and Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.
Star J and Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

Course No.: SOIL 0510
Credit hours: 0+2
Course Title: Analytical Technique and Instrumental Methods in Soil and Plant Analysis

Objectives:

1. To impart knowledge on the basic principles of instruments and their working.
2. To study the various chemical and reagent preparation for qualitative and quantitative analysis.
3. To know the different methods of soil and plant sample analysis.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will familiarize with visible Principles, ultra violet and infrared spectrophotometery, atomic absorption flame-photometry, and plasma spectrometry**.**

CO2: The students will get knowledge of Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis.

CO3: The students will learn preparation for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complex metric titration.

CO4: The students will get knowledge of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium.

CO5: The students will gain an electrochemical titration of clays; estimation of exchangeable cations and estimation of root cation exchange capacity.

	PSO-1	PSO-2	PSO-3
CO1	✔	✔	
CO2	✔		✔
CO3	✔		
CO4			✔
CO5	✔		✔

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.

Suggested Reading

Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes and 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 and 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.

Course No.: SOIL 0511
Credit hours: 2+1
Course title: Management of Problem Soils and Waters
Objectives:

1. To know different soil problems occurring during crop cultivation.
2. To determine the different characteristics of problem soils.
3. To learn different reclamation methods of problem soil to improve soil health and soil fertility.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Students will get knowledge on different types of waste lands and problematic soils.
CO2: Student can analyze various parameters of problematic soils and suggest reclamation and management practices.
CO3: Students will estimate different quality of irrigation water.
CO4: Student will gain good understanding of assessment of soil health and quality, soil pollution and bioremediation.
CO5: Student will learn land capability and land suitability classification and use of remote

sensing in monitoring degraded and problematic soils.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		✔
CO3			✔
CO4	✔		
CO5		✔	

Theory

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; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land 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 in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

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

Suggested Readings

Bear FE. 1964. Chemistry of the Soil. Oxford and IBH.

Jurinak J.J. 1978. Salt- affected Soils. Department of Soil Science and Biometeorology. Utah State Univ.

USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford and IBH.

Course No.: SOIL 0512
Credit hours: 1+0
Course title: Land Degradation and Restoration
Objectives:

1. To learn about different various factors and processes of land degradation.
2. To study the land restoration and conservation techniques for soil erosion.
3. To know about diagnosis and mapping of land degradation.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: The students will familiarize Type, factors and processes of soil, land degradation and its impact on soil productivity

CO2: The students will get knowledge Land restoration and conservation techniques-erosion control.

CO3: The students will learn diagnosis and mapping of land degradation by conventional and modern RS-GIS tools.

CO4: The students will get knowledge how to monitoring land degradation by fast assessment, use of modern tools, land use policy.

CO5: The students will manage the salt affected soil and get idea of afforestation.

	PSO-1	PSO-2	PSO-3
CO1	✓		✓
CO2	✓		
CO3		✓	✓
CO4	✓	✓	
CO5	✓		✓

Theory
Unit I
Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.
Unit II
Land restoration and conservation techniques-erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products.
Unit III
Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Reading

- Biswas TD and Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Soc. Soil Sci. 17, New Delhi.
- Doran JW and Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.
- Greenland DJ and Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.

• Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. *Methods for Assessment of Soil Degradation.* CRC Press.
• Sehgal J and Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

Course No.: SOIL 0513
Credit hours: 2+0
Course title: Soil Survey and Land Use Planning

Objectives:

4. To know different soil surveys and its techniques for better utilization of land.
5. To teach better management of run-off or surplus/ excessive rain-water in the catchment area for agricultural purposes in a watershed.
6. To know land capability classification and land evaluation and land use type of various Indian soils.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Student will gain knowledge on Soil survey and its types and soil survey techniques.
CO2: Student will get acquainted with application of remote sensing and GIS in soil survey and mapping of major soil group of India.
CO3: Student will learn land capability classification; land evaluation and land use type for managing soils and landscapes in the framework of agro-ecosystem.
CO4: Student will get familiar with different concept and techniques of land use planning; factors governing present land use and constraints in application.
CO5: Student will gain deep understanding of different agro-ecological regions/sub-regions of India and their characteristics in relation to crop production.

	PSO-1	PSO-2	PSO-3
CO1	✔	✔	
CO2		✔	
CO3	✔		✔
CO4	✔	✔	
CO5	✔		

Theory

UNIT I: Soil survey and its types; soil survey techniques- conventional and modern; soil series- characterization and procedure for establishing soil series; benchmark soil sand soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for generation of soil maps, application of remotesensing and GIS in soil survey and mapping of major soil group of India.

UNIT II: Landform- soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and landuse type (LUT)- concept and application; approaches for managing soils and land scapes in the framework of agro-ecosystem.

UNIT III: Concept and techniques of land use planning; factors governing present land use; land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT IV: Agro-ecological regions/ sub-regions of India and their characteristics in relation to crop production. Status of Odisha in India.

Practical

Aerial photo and satellite data interpretation for soil and land use Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales land use planning exercises using conventional and RS tools.

Suggested Readings

Boul S.W., Hole E.D., MacCraken R.J. and Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.

Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley and Sons.

Course No.: SOIL 0514

Credit hours: 2+1

Course Title: Introduction to Nanotechnology

Objectives:

1. To teach students the basics of nanoscience and its importance in crop production.
2. To impart basic knowledge about properties of nanoparticles.
3. To know different applications of nanoparticles in biology.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Students will learn basics of quantum mechanics and band structure in solids.

CO2: Students will learn different nanostructures.

CO3: Student will know about nanofabrication and nano patterning of important nanomaterials.

CO4: Student will gain knowledge on different properties of nanoparticles and manipulating materials in the nanoscale.

CO5: Student will know about nano-biology, synthesis of hybrid nano-bioassemblies, nano-biotechnology, nano-sensors and its use in agriculture.

	PSO-1	PSO-2	PSO-3
CO1	✔		
CO2	✔		
CO3	✔	✔	
CO4	✔	✔	
CO5	✔	✔	

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 nano-wires, fullerenes (buckballs, graphene). Nano-fabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nano-powders, electrode position, important nano-materials.

UNITIII: 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 nano-particles and its preparation by different approaches. Electrospinning and its use in agriculture and allied sector. Equipments used in Nano-technology: its principle and uses, Acquaintances with different equipments used in nano-technology, Synthesis and characterization of Ag and ZnO nano-particles. Mode of action of ZnO nano-particles against soil borne diseases. Study on efficacy of ZnO nano-particles as seed treating agent on plant growth parameters.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, oral presentation by students

Suggested Readings

Balandin AA and Wang KL. 2006. *Handbook of semiconductor nano structures and nano devices.* California: American Scientific Publishers.

Timp G. 1999. *Nanotechnology.* New York: Springer Verlag.

Challa Kumar SSR. 2006. *Nanotechnologies for the life sciences*. Weinheim: Wiley-VCHGmbH.

Kohler M and Frintzsche W. 2007. *Nanotechnology: Introduction to nanostructuring techniques* W Weinheim: Wiley-VCH Verlag GmbH.

Kosal ME. 2009. *Nanotechnology for chemicao and biological defense*. Dordrecht: Stringer.

MINOR COURSE

Course No.: AGRO 0504
Credit hour: 2+1
Course Title: Principles and Practices of Water Management

Objectives:

1. To gain knowledge regarding soil-water- plant relationships.
2. To get expertise in efficient water use management.
3. To know the principles of water management and practices to enhance the water productivity, basic skill on water management for optimization of crop yield.

Course Outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: Understand soil-water-plant relationship.

CO2: Gain knowledge on crop water requirement and different types of measurements related to this.

CO3: Get familiarized with different irrigation and drainage methods.

CO4: Get to know issues related to water quality and its management methods.

CO5: Able to learn water management of different field crops.

	PSO1	PSO2	PSO3
CO1	✔		✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

UNIT I: Water and its role in plants; Irrigation: definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

UNIT II: Field water cycle, water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

UNIT III: Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

UNIT IV: Water management of crop and cropping system,Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement-

estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

UNIT V: Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

UNIT VI: Quality of irrigation water and management of saline water for irrigation, water management in problem soils.
UNIT VII: Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.
UNIT VIII: Hydroponics.
UNIT IX: Water management of crops under climate change scenario.

Practical
Determination of Field capacity by field method. Determination of Permanent Wilting Point by sunflower pot culture technique. Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus. Determination of Hygroscopic Coefficient. Determination of maximum water holding capacity of soil. Measurement of matric potential using gauge and mercury type tensiometer. Determination of soil-moisture characteristics curves. Determination of saturated hydraulic conductivity by constant and falling head method. Determination of hydraulic conductivity of saturated soil below the water table by auger hole method. Measurement of soil water diffusivity. Estimation of unsaturated hydraulic conductivity. Estimation of upward flux of water using tensiometer and from depth ground water table. Determination of irrigation requirement of crops (calculations). Determination of effective rainfall (calculations). Determination of ET of crops by soil moisture depletion method. Determination of water requirements of crops. Measurement of irrigation water by volume and velocity-area method. Measurement of irrigation water by measuring devices and calculation of irrigation efficiency. Determination of infiltration rate by double ring infiltrometer.

Suggested Readings:
Majumdar D.K. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers.
Mukund Joshi.2013.A Text Book of Irrigation and Water Management, Kalyani publishers.
Lenka D. 1999. Irrigation and Drainage. Kalyani publishers.
Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.
Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
Prihar SS and Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
Reddy SR. 2000. Principles of Crop Production. Kalyani.
Singh Pratap and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

Course No.: AGRO 0511
Credit hours: 2-0-0
Course Title: Cropping Systems and Sustainable Agriculture

Objectives:

1. To acquaint the students about prevailing cropping systems and practices to improve their productivity.
2. To understand the concept of sustainable agriculture.
3. To impart knowledge on the economic feasibility of adoption of farming system.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Summarized information about prevalent cropping systems of country and its components

CO2: To understand farming systems and its components to increase economic condition of farmers

CO3: To gain knowledge regarding efficient resource management

CO4: To know the role of soil nutrients, manures, and fertilizers to attain sustainability in agriculture.

CO5: Able to know about indices and efficiency related to cropping and farming system as well as sustainable agriculture.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

UNIT-I: Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

UNIT-II: Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

UNIT-III: Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non- monetary inputs and low cost technologies; research need on sustainable agriculture.

UNIT-IV: Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in

intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

UNIT-V: Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

UNIT VI: Artificial Intelligence- Concept and application.

Suggested Reading:

Panda S. C. 2017. Cropping systems and sustainable agriculture. Agrobios (India)
Panda S. C. 2018. Cropping and farming systems. Agrobios.
Palaniappan SP and Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.
Panda S.C. 2003. Cropping and Farming Systems. Agrobios.
Reddy SR. 2000. Principles of Crop Production. Kalyani publishres.

Course No.: AGRO 0512

Credit hours: 2+1

Course Title: **Dryland Farming and Watershed Management**

Objectives:

1. To understand concept and characteristics of Indian rainfall pattern and dryland farming
2. To familiarize with various concepts and characteristics of dry land farming in Indian context
3. To make students know soil and crop management methods in aberrant weather conditions

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Basic knowledge on dryland farming in Indian agriculture

CO2: Understand the rainfall characteristics and drought.

CO3: Gain knowledge regarding stress and physiology and contingent crop planning.

CO4: Know soil and crop management practices in dryland agriculture.

CO5: Get overall idea on watershed management.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

UNIT I: Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

UNIT II: Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

UNIT III: Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

UNIT IV: Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

UNIT V: Concept of watershed resource management, problems, approach and components.

Practical

Method of Seed Priming. Determination of moisture content of germination of important dryland crops. Determination of Relative Water Content and Saturation Deficit of Leaf. Moisture stress effects and recovery behaviour of important crops. Estimation of Potential ET by Thornthwaite method. Estimation of Reference ET by Penman Monteith Method. Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index). Classification of climate by Koppen Method. Estimation of water balance by Thornthwaite method. Estimation of water balance by FAO method. Assessment of drought. Estimation of length of growing period. Estimation of probability of rain and crop planning for different drought condition. Spray of anti-transpirants and their effect on crops. Water use efficiency.

Suggested Reading

Reddy TY. 2018. Dryland Agriculture Principles and Practices, Kalyani publishers.
Das NR. 2007. Tillage and Crop Production. Scientific Publ.
Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.
Dhruv Narayan VV. 2002. Soil and Water Conservation Research in India. ICAR.
Gupta US. (Ed.). 1995. Production and Improvements of Crops for Drylands. Oxford & IBH.
Katyal JC and Farrington J. 1995. Research for Rainfed Farming. CRIDA.
Rao SC and Ryan J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publ.

Course No.: PGPP 0501
Credit hours: 2+1
Course Title: Principles of Plant Physiology I- Plant Water Relations and Mineral Nutrition

Objectives:

1. To impart knowledge in the field of water relations and mineral nutrition.
2. To acquaint knowledge on how plants obtain water and transport it.
3. To summarize various concepts related to stress physiology.

Course outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO 1: Ability to understand soil-plant water relations.

CO 2: Gain knowledge on root functionality, transpiration, and stomatal regulation.

CO3: Understand enhancement of water use efficiency and drought tolerance strategies.

CO4: Get knowledge on Mineral nutrition and their significance.

CO5: Learn nutrient acquisition mechanisms.

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔	✔	✔
CO3	✔	✔	
CO4	✔		✔
CO5	✔		✔

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 trait.

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.

Practicals

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.

Suggested Reading

Goyne, P.J., Milroy, S.P., Lilley, J.M., and Hare, J.M. 1993. Radiation interception, radiation use efficiency and growth of barley cultivars. Australian Journal of Agricultural Research, 44(6), 1351-1366.

https://www.sciencedirect.com/topics/chemistry/photosynthetic-pigment.

Frank, H.A., Young, A., Britton, G., and Cogdell, R.J. (Eds.). 2006. The photochemistry of carotenoids (Vol. 8). Springer Science and Business Media.

Ruban, A.V. 2016. Nonphotochemical chlorophyll fluorescence quenching: mechanism and effectiveness in protecting plants from photodamage. Plant Physiology, 170(4), 1903-1916.

Maxwell, K., and Johnson, G.N. 2000. Chlorophyll fluorescence—a practical guide. Journal of Experimental Botany, 51(345), 659-668.

https://www.researchgate.net/publication/38051229,_The_photochemical_reaction_in_photosynthesis.

Wang, Y., Stessman, D.J., and Spalding, M.H. 2015. The CO_2 concentrating mechanism and photosynthetic carbon assimilation in limiting CO_2: how Chlamydomonas works against the gradient. The Plant Journal, 82(3), 429-448.

Dietz, K.J., and Pfannschmidt, T. 2011. Novel regulators in photosynthetic redox control of plant metabolism and gene expression. Plant Physiology, 155(4), 1477-1485.

Course Code: PGPP 0505 Credit Hours: 2+1

Course Title: Hormonal Regulation of Plant Growth and Development

Objectives:

1. To provide knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signalling.
2. To impart knowledge on role in regulating basic physiological processes.
3. To develop understanding on the role of classical hormones on developmental processes.

Course Outcome: At the end of the course the students will be able to achieve the following outcomes:

CO 1: Understand the role of plant hormones, its discovery and metabolism

CO 2: Enable to understand about various endogenous growth substances other than hormones

CO 3: Gain knowledge on hormone signalling, key genes regulating hormone levels and functions

CO 4: Summarize the Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

CO 5: Acquire knowledge on the Practical Utility of Growth Regulators in Agriculture and Horticulture

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔	✔	
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔		✔

Theory

Block 1: Plant Growth and Development: Hormonal Regulation

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants
and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroids and Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development.

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

Practical

Extraction of Auxins from plant tissue; Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique; Bioassay of auxin- effect on rooting of cuttings; Extraction of abscisic acid (ABA) from plant tissue; Separation and detection of ABA by HPLC/Immunological technique; ABA bioassays- effect on stomatal movement; Preparation of samples for ethylene estimation in plant tissue;Estimation of ethylene in plant tissues using gas chromatography; Ethylene bioassays, estimation using physico-chemical techniques-effect on breaking dormancy in sunflower and groundnut; Extraction of Gibberellins from

plant tissue- GC / GC-MS / HPLC; Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique; GA bioassays- effect on germination of dormant seeds; Cytokinin- extraction from plant tissue; Separation and detection of cytokinin by GC / GC-MS / HPLC; Cytokinin bioassays- effect on apical dominance and senescence / stay green

Suggested Reading

Davies P.J. 2004, *Plant Hormones: Biosynthesis, Signal Transduction and Action,* 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Hedden, P. and Thomas, S.J. 2006. *Plant Hormone Signalling*, Blackwell Publishing Ltd., Oxford, UK.

Osborne, D.J. and McManus, M.T. 2005. *Hormones, Signals and Target Cells in Plant Development*. Cambridge University Press, New York, USA.

Tucker, G.A. and Roberts, J.A. 2000. *Plant Hormone Protocols.* Humana Press-Springer Science, New York, USA.

Buchanan B B, Gruissem W and Jones R L. *Biochemistry and Molecular biology of Plants*, 2nd Edition.

Lincoln Taiz and Eduardo Zeiger. *Plant Physiology and Development*, 6th Edition.

Teaching Tools in Plant Biology, The American Society of Plant Biologists

The Arabidopsis Book(http://www.arabidopsisbook.org/)

SUPPORTING COURSE

Course No.: STAT 0502
Credit hours: **3+1**
Course title: Statistical Methods for Applied Sciences

Objective:

1. To impart concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.
2. To understanding the concepts involved in data presentation, analysis and interpretation.
3. To train students about presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Gain comprehensive knowledge of fundamental statistical concepts, including descriptive statistics, probability theory, and the principles of exploratory data analysis.

CO2: Understanding discrete and continuous probability distributions their applications in real-world problems. CO3: Proficient in conducting statistical inference, interpreting correlation coefficients, and performing regression analysis.

CO4: Developing skills to perform non-parametric tests as valuable alternatives to parametric tests.

CO5: Students equipped with advanced statistical techniques, enabling effective application of statistical methods in real-world research and analysis.

	PSO1	PSO2	PSO3
CO1	✔		
CO2		✔	
CO3		✔	
CO4	✔		
CO5	✔		

Theory

UNIT I: Box-Plot and Descriptive Statistics, Exploratory data analysis; Theory of probability, Random Variable and mathematical expectation.

UNIT II: Discrete and continuous probability distributions: Binomial, Poisson and Normal 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.

Suggested Reading

Goon A.M, Gupta M.K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.

Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.

Hoel P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.

Hogg R.V and Craig T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.

Morrison D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.

Hogg RV, McKean JW, Craig AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.

Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

Anderson TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed . John Wiley.

http://freestatistics.altervista.org/en/learning.php.

Statistics Text Book:http://www.statsoft.com/textbook/stathome.html.

Credit hr. 3(2+1)
Course No.: STAT 0511
Credit hours: 2+1
Course Title: Experimental Designs
Objectives:

1. To understand the concepts involved in planning, designing their experiments and analysis of experimental data
2. To explore the basic principles of experimental design, including the concept of uniformity trials, the size and shape of plots and blocks.
3. To train about fundamental experimental designs (CRD, RBD and LSD) including split plot and strip plot design.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Understanding the basic principles of experimental design.

CO2: Enable learners to plan and implement experiments using basic designs (CRD, RBD and LSD).

CO3: Familiarized in conducting both symmetrical and asymmetrical factorial experiments

CO4: Execute split plot and strip plot experiments enhancing their agricultural research capabilities.

CO5: Able to use bioassays (direct and indirect) based on quantal dose response.

	PSO1	PSO2	PSO3
CO1	✔	✔	
CO2	✔	✔	
CO3		✔	
CO4		✔	
CO5	✔		

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 and LSD; Analysis of Factorial Experiments; Analysis with missing data; Split Plot and Strip Plot Designs.

Suggested Reading

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
Federer WT. 1985. Experimental Designs. MacMillan.
Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design

Course No.: STAT 0512
Credit hours: 2+1
Course Title: Basic Sampling Techniques
Objectives:

1. To expose students to various elementary sampling techniques
2. To understand the concepts involved in planning and designing their surveys
3. To present of result of sample survey data

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Enlighten on different basic terms on sampling techniques

CO2: Students gain exposure about fundamental sampling techniques

CO3: Learning sampling methods (e.g., cluster, systematic, PPS) for effective data collection in research and surveys

CO4: Equip proficiency in using auxiliary information for estimation, employing ratio product and regression estimators to enhance accuracy

CO5: Developing skills in double sampling and the identification and rectification of sampling and non-sampling errors to improve research and survey results

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔		
CO3	✔		
CO4		✔	
CO5		✔	

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.

Suggested Reading

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

Course No.: STAT 0522
Credit hours: **2+1**
Course Title: **Data Analysis using Statistical Packages**

Objectives:

1. To expose the students in the usage of various statistical packages for analysis of data.
2. To provide the students and hands on experience in the analysis of their research data.
3. To impart the skills to students in carrying out data interpretation and result explanations.

Course Outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Summarizing and tabulating data, performing descriptive statistics, and creating graphical representations for effective data exploration.

CO2: Fitting and assessing the goodness of fit of probability distributions, as well as conduct hypothesis testing using various statistical tests.

CO3: Performing advanced analyses, including analysis of variance and covariance for different experimental designs.

CO4: Analysing mixed models, estimating variance components, testing contrasts' significance, and conducting correlation and regression analyses.

CO5: Competence in advanced data analysis techniques.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

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.

Suggested Reading

Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley.

Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.
Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman and Hall.
Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University
Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.
Cleveland WS. 1994. *The Elements of Graphing Data*, 2nd Ed., Chapman & Hall
http://freestatistics.altervista.org/en/learning.php.
http://freestatistics.altervista.org/en/stat.php.
http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
http://www.stat.sc.edu/~grego/courses/stat706/.
www.drs.icar.gov.in.

COMMON COURSES

The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

Course No.: PGSS 0501
Credit hours: 0+1
Course Title: Library and Information Services

Objective:

1. To equip the library users with skills to trace information from libraries efficiently.
2. To apprise students abou information and knowledge resources, to carry out literature survey.
3. To formulate information search strategies, with the application of modern tools.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Acquaint with basic terms of library services
CO2: Understand the methods of tracing information from different source.
CO3: Enable ability to relate one information with another information of interest.
CO4: Gain knowledge on abstracts, review collection, citation, bibliography and tracking information.
CO 5: Develop ability to compose of review of literatures and scientific reports.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical abstracts, CABI Abstracts, etc.); tracing information from reference sources; Literature survey; Citation techniques /Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; eresources access methods.

Course No.: PGSS 0502
Credit hours: 0+1
Course Title: Technical Writing and Communications Skills

Objective:

1. To equip the students/scholars with skills to write dissertations, research papers, etc.
2. To impart the students/scholars with skills to communicate and articulate in English (verbal as well as writing).
3. To familiarize the students on composing abstracts, review articles, research paper writing etc.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1 Educate about the various forms of writings frequently required in a preparation of documents, reports, manuscripts, manual, etc.

CO2 Develop the understanding of principles and method of effective and professional communication and speech.

CO3 Students able to differentiate among and to use facts, inferences and judgments and editing and proof-reading and

CO4 Enable students to organizing information for research communication, report, thesis and other publication

CO5 Equip the skills in composing the abstracts, content, notation, citation, captions, pagination, bibliography, review of literature, scientific manuscript, research article, review article, etc.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical

Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, precis, citations, etc.; Commonly used abbreviations in the theses and research communications; llustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; writing of numbers and dates in scientific write -ups; Editing and proof-reading; Writing of a review article; Communication Skills-Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis

(Common errors), Concord, Collocation, Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech; Participation in group discussion; Facing an interview; Presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14thEd. 1996 Prentice Hall of India.
Collins' Cobuild English Dictionary.1995.
Harper Collins.Gordon HM & Walter JA. 1970.Technical Writing 3rd Ed.
Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
Richard WS. 1969. *Technical Writing*.
Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

Course No.: PGSS 0503
Credit hours: 1+0
Course Title: Intellectual Property and its Management in Agriculture

Objective:

1. To equip students and stakeholders with knowledge of intellectual property right
2. To give the significance of fundamentals of patient and copyright policy
3. To impart knowledge and biodiversity protection and initiatives

Course outcomes: At the end of the course, the students will be able to achieve following outcomes;

CO1: Acquaint the meaning of intellectual property and differentiate it from tangible property.

CO2: Understand the process of IPR, their eligibility and various treaties and conventions.

CO3: Develop the ability to analyze TRIPs and various provisions in TRIPS Agreement, GI, ITK.

CO4: To understand protection of plant varieties, researcher's right and farmers' right.

CO5: Enable to evaluate ethical and professional issues that arise in the intellectual property law.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔

CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License agreement.

Suggested Readings

Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

Course No.: PGSS 0504

Credit hours: 0+1

Course Title: Basic Concepts in Laboratory Techniques

Objective:

1. To acquaint the students about the basics of commonly used techniques in laboratory.
2. To impart various handling techniques and preparation of acid and bases.

3. To learn seed viability testing tissue culture of plants and description of flowering.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Educate about basic rules and regulations of laboratory use

CO2: Acquaint with the principles and protocols of commonly used instruments in soil sciences.

CO3: Ability to understand principles and methods of handling chemicals and equipment, preparation of solution, testing samples, etc. in the laboratory.

CO4: Enhance the skills to operate laboratory equipment efficiently and safely

CO5: Students will be able to design appropriate procedure of scientific works in the laboratory in such a way that accuracy of results remains higher.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; preparation of different agro-chemical doses in field and pot application; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.

Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Course No.: PGSS 0505

Credit hours: 1+0

Course Title: Agricultural Research, Research Ethics and Rural Development Programmes

Objective:

1. To enlighten the students about the organization and functioning of agricultural research systems at national and international levels.
2. To impart knowledge in programs and policies of Government.
3. To provide information and evaluation of rural development policies and programs.

Course outcome: At the end of the course, the students will be able to achieve following outcomes;

CO1: Impart the knowledge about basics of Agricultural Research, Research Ethics and Rural Development Programs in India

CO2: Develop the understanding of research ethics

CO3: Ability to develop and understanding of rural developmental programs, policies, strategies and their evaluation system.

CO4: Get insights into intensive agriculture development programs.

CO5 : Able to analyze the constraints in implementation of rural policies and programs.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

UNIT I: History of agriculture in brief; Global agricultural research system: need, scope, opportunitites; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural research(CGIAR): International Agricultural Research centres(IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II: Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III: Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group- Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary agencies/Non-Governmental Organizations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS and Singh G. 2001.Indian Agriculture- Four Decades of Development. Sage Publ.

Punia MS. Manual on International Research and Research Ethics.CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives. Mittal Publ.

Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.