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
2022

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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 ofmacro and micro nutrients in soils, plants, animal nutrition and in food for man. The skillsof several scientific disciplines, combined with sophisticated instruments, have extendedour 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 differentprocesses, concepts and development so as to develop competencies on the area ofspecialization 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. (Ag) 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 MSc 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 (ii) Modelling of soil plant system(iv)Claymineralogy.

Content

Framework of the courses

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

Courses	M.Sc. (Agri.) Credits
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
Thesis	30
Total	70

M.Sc. (Agri.) Soil Science

Couse Code	Course Title	Credits	Page No.
Major Courses			
SOIL 0501*	Soil Physics	2+1	3
SOIL 0502*	Soil Fertility and Fertilizer Use	2+1	5
SOIL 0503*	Soil Chemistry	2+1	6
SOIL 0504*	Soil Mineralogy, Genesis and Classification	2+1	9
SOIL 0505	Soil Erosion And Conservation	2+1	10
SOIL 0506	Soil Biology and Biochemistry	2+1	12
SOIL 0507	Radioisotopes in Soil and Plant Studies	1+1	13
SOIL 0508	Soil, Water and Air Pollution	2+1	15
SOIL 0509	Remote Sensing and GIS Technique For Soil And Crop Studies	2+1	16
SOIL 0510	Analytical Technique and Instrumental Methods In Soil and Plant Analysis	0+2	17
SOIL 0511	Management of Problematic Soils and Water	1+1	19

SOIL 0513	Soil Survey And Land Use Planning	2+0	20
SOIL 0514	Introduction To Nanotechnology	2+1	21
SOIL 0591	Master's Seminar	1+0	
SOIL 0599	Master's Research	30	
Minor Courses			
AGRO 0504	Principles and practices of water management	2+1	23
AGRO 0511	Cropping system for sustainable agriculture	2+0	25
AGRO 0512	Dryland Farming and Watershed Management	2+1	27
PGPP 0501	Principles of Plant Physiology I: Plant Water Relations and Mineral Nutrition	2+1	28
PGPP 0504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1	31
PGPP 0505	Hormonal Regulation of Plant Growth and Development	2+1	34
PGPP 0507	Photosynthetic process crop growth productivity of growth, concept of yield and crop modelling	2+1	37
Supporting Courses			
STAT 0502	Statistical methods for applied sciences	3+1	40
STAT 0511	Experimental designs	2+1	41
STAT 5012	Basic Sampling Techniques	2+1	42
STAT 0522	Data Analysis Using Statistical Packages	2+1	43
Common courses			
PGSS 0501	Library and information services	1+0	45
PGSS 0502	Technical writing and communications Skills	1+0	45
PGSS0503	Intellectual property and its management in agriculture	1+0	46
PGSS0504	Basic concepts in laboratory techniques	1+0	47
PGSS0505	Agricultural research, research ethics and rural Development programmes	1+0	48

***Indicates core course which is compulsory course for M Sc.(Agri.)**

M.Sc. (Agri) Soil Science

MAJOR COURSES

Course Code: SOIL 0501
Credit Hours: 2+1
Course Title: Soil Physics

Objective: To impart basic knowledge about soil physical properties and processes in relation to plant growth.

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 ofhydraulic 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; soiltemperature management.

Practical

- Determination of B.D, P.D 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.

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

Learning outcome: Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. Soil Physics. John Wiley & Sons.
Ghildyal BP & Tripathi RP. 2001. Soil Physics. New Age International. Hanks JR & 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.

Course Code : SOIL 0502
Credit Hours: 3+1
Course Title: Soil Fertility and Fertilizer Use

Objective: To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

UNIT I

Soil fertility and soil productivity; fertilitystatus 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 andalkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soilsand management under field conditions. Potassium - forms, equilibrium in soils and its agriculturalsignificance; mechanism of potassium fixation; management of potassium fertilizers under fieldconditions.

UNIT V

Sulphur - source, forms, fertilizers and their behavior in soils; role incropsand 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– intensityrelationships; 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,needand category.CurrentstatusofspecialityfertilizersuseinsoilsandcropsofIndia;

UNIT IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soilquality in relation to sustainable agriculture, Determination of critical limit, DRIS

UNIT X

Definitionand conceptsofsoil healthand soil quality; Long term effectsoffertilizersandsoilqu ality.

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)

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

Learning outcome: Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. Soil Physics. John Wiley & Sons.
Ghildyal BP & Tripathi RP. 2001. Soil Physics. New Age International.
Hanks JR & Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic

Course Code : SOIL 0503
Credit Hours: 2+1
Course Title: Soil Chemistry

Objective: To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

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), adsorptionisotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange –innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin 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 specificand non-specific sorption; precipitation-dissolution equilibria; Concepto quantity/intensity(Q/I)relationship;step and constant-rate K; managementaspects.

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, HCO, 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 andconductivity 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 theΔ (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 BaCl2-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.

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

Learning outcome: Experience on the knowledge of chemical behaviour of soil and their utility in research for solving field problem.

Suggested Readings

Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
Bolt GH &Bruggenwert MGM. 1978. Soil Chemistry. Elsevier. Greenland DJ & Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
Greenland DJ & Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press. Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ.

Course Code: SOIL 0504
Credit Hours. 2+1
Course Title: Soil Mineralogy, Genesis, Classification and Survey

Objective: To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable

students conduct soil survey and interpret soil survey reports in terms of land use planning.

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.

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

UNIT V

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

UNIT VI

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

Practical

- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation

- Grouping soils using available data base in terms of soil quality
- 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.

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

Learning outcome: Experience on the knowledge of soil taxonomy and genesis and and their utility in research for solving field problem.

Suggested Readings

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

Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.

Dixon JB & Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison.

Course Code : SOIL 0505
Credit Hours: 2+1
Course Title: Soil Erosion and Conservation

Objective: To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

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 ; 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 watersheds

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

Learning outcome: Experience on the knowledge of soil conservation and their utility in research for solving field problem.

Suggested Readings

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

Doran JW & 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 & Joshi BP. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.

Hudson N. 1995. Soil Conservation. Iowa State Univ. Press.
Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.

Couse Code: SOIL 0506
Credit Hours 2+1
Course Title: Soil Biology and Biochemistry

Objective: To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

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.

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

Biodegradation of pesticides, 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.

Practical

- Determination of soil microbial population
- Determination of Soil microbial biomass

- Determination of Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil,
- Determination of Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation,
- Determination of S oxidation
- Determination of P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect.

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

Learning outcome: Experience on the knowledge of soil taxonomy and genesis and and their utility in research for solving field problem.

Suggested Readings

Alexander M. 1977. Introduction to Soil Microbiology. John Wiley & Sons.
Burges A & Raw F. 1967. Soil Biology. Academic Press.

Course Code: SOIL 0507
Credit Hours: 1+1
Course Title: Radioisotopes in Soil and Plant Studies

Objective: To train students in the use of radio isotopes in soil and plant research.

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

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of radio activity and their utility in research for solving field problems.

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 Code : SOIL 0508
Credit Hours : 2+1
Course Title: Soil, Water and Air Pollution

Objective: To make the student saw are of the problems of soil, water and air pollution associated with use of soils for crop production.

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 effecton soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV

Pesticides–their classification, behaviour in soil and effecton 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 green house gases–carbondioxide, 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 soil and plants and their processing
- Measurement 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 ineffluents, Heavy metals in contaminated soils and plants
- Management ofcontaminants in soil and plants to safe guard food safety, Air sampling anddetermination of particulate matter and oxides of sulphur, NO2 and O2 conc
- Visit to various industrial sites to study the impact of pollutants on soil and plants.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Management of soil and water pollution

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 & Sons.

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

Course Code : SOIL 0509

Credit Hours: 2+1

Course Title: Remote sensing and Gis Technique for Soil, Water and Crop Studies

Objective: To impart knowledge about the basic concepts of remote sensing, aerial photographs andimageries, and their interpretation; application of remote- sensingin general and with special reference tosoil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

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 sandscanners; fundamentals of aerial photographs and multispectralimaging, hyperspectral imaging,thermal imaging; image processing and interpretations.

UNIT III

Application of remote sensing techniques- landuse soil surveys, crop stress and yield fore casting, 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 in relation to size of sampling; classicalandgeo-statisticaltechniques of evolutionofsoil variability.

UNIT V

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

Practical

- Familiarization with differentr emote sensing equipments and data products, Interpretation of aerialphotographsand satellite data for mapping of and resources
- Analysis of variability of differentsoil properties with classical and geostatistical techniques
- Creation of data files in adata base programme,
- Use of GIS for soils patial simulation and analysis
- To enable the students to conduct soil survey and interpret soil survey reports interms of land use planning.

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

Learning outcome: Experience on the knowledge of remote sensing and their utility in research for solving field problem.

Suggested Readings

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

Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.

Course Code : SOIL 0510

Credit Hours : 0+2

Course Title: Analytical Technique and Instrumental Methods in Soil and Plant Analysis

Objective: To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

- 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.
- Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium
- Estimation of phosphorus, ammonium and potassium fixation capacities of soils.
- 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.
- Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.
- 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
- Drawing normalized exchange isotherms; measurement of redox potential.

Teaching methods/activities: Classroom teaching and laboratory practicals

Learning outcome: Development of confidence for setting soil testing laboratory.

Suggested Reading

• Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
• Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
• Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
• Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.
• Page AL, Miller RH and Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
• Piper CE. Soil and Plant Analysis. Hans Publ.
• Singh D, Chhonkar PK and Pandey RN. 1999. Soil Plant Water Analysis - A Methods Manual. IARI, New Delhi.
• Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
• Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
• Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.

Course Code: SOIL 0511
Credit Hours: 2+1
Course Title: Management of Problem Soils and Waters

Objective: To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

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-, SO4—, CO3— and HCO3-) 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 & IBH.

Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology.Utah State Univ.

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

Course Code : SOIL 0513
Credit Hours: 2+0
Course Title: Soil Survey and Land Use Planning

Objective: To teach the better utilization of land for agricultural purposes, and better management of run- off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

UNIT I

Soil survey and its types; soil survey techniques- conventional and modern; soil series– characterization and procedure for establishing soil series;benchmark soils and soil correlations; soil survey interpretations; the matic soil maps, cartography, mappingunits ,techniques for generation of soil maps, application of remote sensing 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 ;land evaluation and land use type(LUT)– concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

UNITIII

Concept and techniques of land use planning; factors governing present landuse; Land evaluation methods and soil-site uitability evaluation for different crops; land capability classification and constraints in application.

UNITIV

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 map sand them at icmaps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercise susingconventionalandRStools

Teaching methods/activities: Classroom teaching with AV aids, group discussion, field visit and exposure visit

Learning outcome: Planning for land use in proper way for higher crop productivity.

Suggested Readings

Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.

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

Course Code : SOIL 0514
Credit Hours : 2+1
Course Title: Introduction to Nanotechnology

Objective: To impart basic knowledge about nanoscience, properties of nanoparticles and their applications in biology

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

Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nanowires, fullerenes (buckballs, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nanopowders, electrode position, important nanomaterials.

UNIT III

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

UNIT IV

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

Practical

- Sources of nanoparticles and its preparation by different approaches
- Electrospinning and its use in agriculture and allied sector.
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nanoparticles.

• Mode of action of ZnO nanoparticles against soil borne diseases
• Study on efficacy of ZnO nanoparticles as seed treating agent on plant growth parameters.

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

Learning outcome: Basic knowledge on nanotechnology and its use in soil science

Suggested Readings

Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.
Brewer R. 1976. *Fabric and Mineral Analysis of Soils.* John Wiley & Sons.

MINOR COURSES

Course Code: AGRO 0504
Credit Hour: 2+1
Course Title: Principles and Practices of Water Management

Objective: To teach the principles of water management and practices to enhance the water productivity

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, extentof 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 PlateApparatus
- 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

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome: Basic knowledge on water management for optimization of crop yield

Reading materials:

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 Hardcover , Kalyani publishers

Lenka D. 1999. Irrigation and Drainage. Kalyani.

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 & Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.Reddy SR. 2000. Principles of Crop Production. Kalyani.

Singh Pratap&Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

Course Code: AGRO 0511
Credit Hours: 2+0
Course Title: Cropping Systems and Sustainable Agriculture

Objective: To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

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 insustainability.

UNIT VI

Artificial Intelligence- Concept and application.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment.

Learning outcome: Basic knowledge on cropping system for sustainable agriculture.

Reading materials:

Panda S. C. (2017). Cropping systems and sustainable agriculture. Agrobios (India)Panda S. C. (2018) Cropping and farming systems. Agrobios.

Palaniappan SP &Sivaraman K. 1996. *Cropping Systems in the Tropics;Principles and Management.* New Age.

Panda SC. 2003. *Cropping and Farming Systems*. Agrobios.Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Sankaran S &Mudaliar TVS. 1997. *Principles of Agronomy.* The Bangalore Printing &Pub.

Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.

Tisdale SL, Nelson WL, Beaton JD &Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

Course Code. : AGRO 0512

Credit Hours : 2+1

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

Objective: To teach the basic concepts and practices of dry land farming and soil moisture conservation.

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 ny 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

Teaching methods/activities
Classroom teaching with AV aids, group discussion, assignment.

Learning outcome
Basic knowledge on dry land farming and soil moisture conservation.

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 forDrylands. 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 Code: PGPP 0501
Credit Hours: 2+1
Course Title: Principles of Plant Physiology I - Plant Water Relations and Mineral Nutrition

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

A. Plant Water Relations

1. Soil and Plant Water Relations
2. Water Absorption and Translocation
3. Transpiration and Evaporative Cooling
4. Water Productivity and Water Use Efficiency
5. Moisture Stress and Plant Growth

B. Mineral Nutrition

1. Nutrient Elements and their Importance
2. Nutrient Acquisition
3. Concept of Foliar Nutrition

Theory

Block A: Plant Water Relations

UNIT I

Soil and Plant Water Relations Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit II

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

UNIT III

Transpiration and Evaporative Cooling Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

UNIT IV

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

UNIT V

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

Block B: Mineral Nutrition

UNIT I

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

UNIT II

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

UNIT III

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

Practical

- Standard solutions and preparation of different forms of solutions
- Studies on the basic properties of water
- Demonstration of surface tension of water and other solvents
- Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
- Determination of soil moisture content and soil water potential
- Use of soil moisture probes and soil moisture sensors
- Measurement of transpiration rate in plants; use of porometry

- Measurement of CCATD and its relevance
- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toxicity symptoms of nutrients
- Effect of water stress on plant growth and development

Suggested Reading

Vilalta JM and Forner NG. 2017. Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydricconcept Plant, Cell and Environment 40, 962–976

Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation. Chapter 16, pp 339–354.

McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. Water Uptake and Transport in Vascular Plants. Nature Education Knowledge 4(5): 6

Hodson RC and J Acuff. 2006. Water transport in plants: anatomy and physiology. Pages 163-183, Tested Studies for Laboratory Teaching, Volume 27 (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.

Chater CCC, Caine RS, Fleming AJ, Gray JE. 2017. Plant Physiology, 174 (2) 624-638; DOI: 10.1104/pp.17.00183

Dietrich P, Sanders D, Hedrich R. 2001. The role of ion channels in light dependent stomatal opening, Journal of Experimental Botany, Volume 52, Issue 363, Pages 1959–1967, https://doi.org/10.1093/jexbot/52.363.1959

Sreeman SM, Vijayaraghavareddy P, Sreevathsa R, Rajendrareddy S, Arakesh S, Bharti P, Dharmappa P, Soolanayakanahally R. 2018. Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants. Front. Chem. 6, 92.

Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, (2016). Drought Stress in Plants: Causes, Consequences, and Tolerance. Drought Stress Tolerance in Plants, Vol 1 pp 1-16

Pandey R. 2015. Mineral Nutrition of Plants. 10.1007/978-81-322-2286-6_20.

Course Code : PGPP 0504
Credit Hours : 2+1
Course Title: Physiological and Molecular Responses of Plants to Abiotic Stresses

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

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

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

UNIT II
Stress Perception and Molecular Responses of Plants to Drought
Stress: Stress perception andsignal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

UNIT III
Plant Adaptive Mechanisms to Drought
(a) Escape and desiccation avoidance mechanism Concept of stress escape- exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatalfactors guard cell metabolism, moisture conservation by waxes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model. (b) Desiccation tolerance- Concept of acquired tolerance. Decreased turgor mediated upregulation of

cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photoprotection of chlorophylls.

UNIT IV

Approaches to Improve Drought Tolerance Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.Salt, Heavy Metal, Water Logging, Temperature and Light Stress

UNIT I

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

UNIT II Heavy Metal Stress and Water Logging :Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

UNIT III

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

Practical

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

Heat tolerance and membrane integrity- Sullivans heat tolerance test.

- Quantification of osmolytes – proline under stress.

• Oxidative stress imposition- Quantification of oxidative stress
• Quantification of ROS under stress.
• Estimation of ABA content in leaf and root tissues under stress.
• Determination of Sodium and Potassium in plant tissue grown under salt stress.
• Estimation of antioxidant enzymes.

Teaching methods/activities

Lecture , Assignment (Reading/Writing), Student presentation. Practicals

Learning outcome

After completion of this course students are expected to have knowledge on and insight into the physiological and molecular responses of plants to abiotic stresses. The student will develop critical insight in adaptive mechanisms of plants against various abiotic stresses.

Suggested Reading:

• Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.
• Plant Physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B
• Pereira A. 2016. Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci. 7: 1123. doi: 10.3389/fpls.2016.01123
• Sergey Shabala, 2012. Plant Stress Physiology.
• https://www.mapsofindia.com/maps/india/drought-prone-areas.html
• Abid M, Ali S, Qi LK, Zahoor R, Tian Z, Jiang D, Snider JL and Dai T. 2018. Physiological and biochemical changes during drought and recovery periods at tillering and jointing stages in wheat (Triticum aestivum L.). Scientific Reports, 8(1), p.4615.
• Fathi, Amin and Barari, Davood. 2016. Effect of Drought Stress and its Mechanism in Plants. International Journal of Life Sciences. 10. 1. 10.3126/ijls.v10i1.14509.
• Pareek A, Sopory SK, Bohnert HJ and Govindjee 2010. Abiotic Stress Adaptation in Plants, Springer, The Netherlands

Course Code: PGPP 0505
Credit Hours: 2+1
Course Title: Hormonal Regulation of Plant Growth and Development

Objective: It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants.The role of classical hormones on developmental processes from germination, shoot and root apical meristem differentiation, flowering, seed maturation and senescence. The aim of this course is to appraise the students about structure and function of plant growth regulators. The course is organized as follows:

A. Plant Growth and Development:

1. Introduction to Plant Hormones Hormonal Regulation
2. Plant Hormones - Discovery and Metabolism
3. Physiological Role of Hormones in Plant Growth and Development
4. Endogenous Growth Substances other than Hormones
5. Hormone Signaling
6. Key Genes Regulating Hormone Levels and Functions
7. Crosstalk of Hormones in Regulation of Plant Growth and Development Processes
8. Practical Utility of Growth Regulators in Agriculture and Horticulture

Theory

Block 1: Plant Growth and Development: Hormonal Regulation

UNIT I

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 II

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 III

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 Brassinosteroidsand 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 IV

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 V

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 VI

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 VII

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/).

Course No: PGPP 0507
Credit Hours: 2+1
Course Title: Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling

Objective: Agronomic inputs and environmental factors enhance crop growth by improving photosynthetic processes and photosynthetic partitioning.

Theory

Block 1: Photosynthetic Processes
UNIT I

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

UNIT II

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

UNIT III

Biochemical Processes CO2 diffusion and resistances (gs and gm). Concept of Ci determining CO2 diffusion. RuBisCO activation state, kinetics and catalytic properties, Carboxylation processes in C3, C4 and CAM plants and their relevance, CO2 concentrating mechanisms and their importance in improving carbon assimilation, Ecological significance of C4 and CAM photosynthesis, Photorespiration and Mitochondrial respiration and net carbon gain, Carbon isotope discrimination and its importance as a surrogate of Ci.

UNIT IV

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

UNIT V

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

Block 2: Yield Improvement and Modelling

UNIT I

Molecular Options to Improve Photosynthesis, Growth and Productivity Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities. Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR etc), Theoretical concepts of crop improvement through inducing CCM in C3 plants and reducing photorespiration.

UNIT II

Fundamentals of Dynamic Simulation Models Collection of crop specific genetic coefficient, Crop, soil and historic weather data

UNIT III

Description of Well-established Yield Models Application and limitations of modeling, Yield prediction models such as APSYM, PeanutGrowetc, Machine learning approaches and IoT for making informed onfarm decisions.

UNIT IV

Examples of Robust Models Extensively Used Duncan'syield prediction model, Passioura'smodelfor growth maximising.

Practical

• Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
• Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized.
• Gas exchange: principles and uses to assess variations in CO2 and water vapour transfer, determination of A/gs and intrinsic WUE
• Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN
• Chlorophyll fluorescence and quenching coefficients
• Theoretical aspects of carbon isotope fractional and its use in determining WUE
• Quantification of RuBisCO content by ELISA (if possible)
• Determination of RuBisCO activity and activation state using radioactive CO-2
• CO2 and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
• Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models

Teaching methods/activities: Lecture, Assignment (Reading/Writing), Student presentation, Practicals

Learning outcome

After completion of this course students are expected to have in depth knowledge on Photosynthetic processes associated with product synthesis and yield development. Students will also obtain current knowledge on various crop models.

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 CO2 concentrating mechanism and photosynthetic carbon assimilation in limiting CO2: 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.
• Farquhar, G.D., Ehleringer, J.R., and Hubick, K.T. (1989). Carbon isotope discrimination and photosynthesis. Annual Review of Plant Biology, 40(1), 503-537.

SUPPORTING COURSES

Course Code: STAT 0502
Credit Hours: **3+1**
Course Title: Statistical Methods for Applied Sciences

Objective: This course is developed to provide exposure of statistical methods to the students who do not have sufficient background of statistics. The students would be exposed to the basic statistical methods which include probability, estimation, tests of significance and correlation and regression.

Theory

UNIT I

Classification, Tabulation and Graphical Representation of data, 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, Large Sample theory.

UNIT III

Introduction to theory of estimation and confidence intervals; Correlation and regression, Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients, Coefficient of Determination, Testing for heterogeneity.

UNIT IV

Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test and Wald-Wolfowitz run test; Run test for the randomness of a sequence. Median test, Kruskal-Wallis test, Friedman two-way ANOVA by ranks and Kendall's coefficient of concordance.

Practical

- Exploratory data analysis
- Box-Cox plots; Fitting of distributions ~ Binomial, Poisson and Normal
- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F
- Confidence interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution
- Correlation and regression analysis
- Nonparametric tests.

References

Goon AM, Gupta MK &Dasgupta B. 1977. An Outline of Statistical Theory.Vol. I. The World Press. Goon AM, Gupta MK &Dasgupta B. 1983. Fundamentals of Statistics.Vol. I.The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics.John Wiley.

Course Code: STAT 0511
Credit Hours: 2+1
Course Title: Experimental Designs

Objective: This course is developed to meet the requirements of students of agriculture and animal sciences other than Statistics. The students would be exposed to the techniques of planning, designing of experiments as well as analysis of experimental data.

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), Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split Plot and Strip Plot Designs, Analysis of Covariance and Missing Plot Techniques in Randomized Block and Latin Square Designs; Transformations, Lattice Design - concepts, randomization procedure, analysis and interpretation of results. Response Curves and Surfaces, Experiments with mixtures.

UNIT V

Introduction to Bio-assays with applications- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

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 without and with Confounding
- Analysis with missing data
- Split Plot and Strip Plot Designs
- Transformation of data
- Fitting of response Curves and Surfaces.

References

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.

Course Code : STAT 0512

Credit Hours : 2+1

Course Title: Basic Sampling Techniques

Objective: This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

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 Code : STAT 0**522**
Credit Hours : **2+1**
Course Title: **Data Analysis using Statistical Packages**

Objective: This course is meant for exposing the students in the usage of various statisticalpackages for analysis of data. It would provide the students a hand on experience in the analysis of their research data. This course is useful to all disciplines.

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 & 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

COMMON COURSES

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

Course Code: PGSS 0501
Credit Hours: 0+1
Course Title: Library and Information Services

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

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
- E-resources access methods.

Course Code: PGSS 0502
Credit Hours: 0+1
Course Title: Technical Writing and Communications Skills

Objective: To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing)

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, précis, citations etc.
- Commonly used abbreviations in the theses and research communications
- Iillustrations, 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 IndiaCollins' Cobuild English Dictionary.1995
Harper Collins.Gordon HM & Walter JA. 1970.
Technical Writing 3rdEd. Holt, Rinehart & Winston'abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research.

Course Code: PGSS 0503
Credit Hours: 1+0
Course Title: Intellectual Property and its Management in Agriculture

Objective: The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and

use of IPR as a tool for wealth and value creation in a knowledge-based economy.

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 &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 & Aesthetic Technologies.

Course Code: PGSS 0504
Credit Hours: 0+1
Course Title: Basic Concepts in Laboratory Techniques

Objective: To acquaint the students about the basic of commonly used techniques in laboratory.

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 taxonom.

Suggested Readings

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

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

Course Code: PGSS 0505
Credit Hours: 1+0
Course Title: Agricultural Research, Research Ethics and RuralDevelopment Programmes

Objective: To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research, and rural development programmes and policies of Government.

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 & 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.