

**Restructured and revised syllabi of PG Courses from the Department of
Soil Science and Agricultural Chemistry**

**Course Title with Credit Load
of Master Degree in Soil Science**

Course Code	Course Title	Credit Hours
*Soil 501	Soil physics	3 (2+1)
*Soil 502	Soil fertility and fertilizer use	3 (2+1)
*Soil 503	Soil chemistry	3 (2+1)
*Soil 504	Soil mineralogy, genesis and classification	3 (2+1)
Soil 505	Soil erosion and conservation	3 (2+1)
Soil 506	Soil Biology and Biochemistry	3 (2+1)
Soil 507	Radioisotopes in soil and plant studies	2 (1+1)
Soil 508	Soil, water and air pollution	3 (2+1)
Soil 509	Remote sensing and GIS technique for soil and crop studies	3 (2+1)
Soil 510	Analytical technique and instrumental methods in soil and Plant Analysis	2 (0+2)
Soil 511	Management of problematic soils and water	2 (1+1)
Soil 512	Land degradation and restoration	1 (1+0)
Soil 513	Soil Survey and Land use Planning	2 (2+0)
Soil 514	Introduction to nanotechnology	3 (2+1)
MICRO 511	Biofertilizer Technology	3 (2+1)
AP 510	Soil Physical Environment and Plant Growth	3 (2+1)
AC 510	Pesticide Residue Chemistry	3 (2+1)
BIOCHEM 501	Basic Biochemistry	4 (3+1)
BIOCHEM 505	Techniques in Biochemistry	4 (2+2)
Soil 591	Master's Seminar	1 (0+1)
Soil 599	Master's Research	30 (0+30)

*Indicates Core Courses which are Compulsory for Master Programme

Course contents of Master Degree in Soil Science

Course Title	: Soil Physics
Course Code	: Soil 501
Credit Hours	: 2+1

Aim of the course

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 of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

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

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils;

energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical:

- Determination of 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.

Learning outcome

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

Course Title : Soil Fertility and Fertilizer Use

Course Code : Soil 502

Credit Hours : 2+1

Aim of the course:

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

Unit II

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

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

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

Unit IX

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

Unit X

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

Practical:

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

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development and also generate knowledge of employment of the learner to the fertilizer industry.

Course Title : Soil Chemistry

Course Code : Soil 503

Credit Hours : 2+1

Aim of the course:

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), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V

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

Unit VI

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

Unit VII

Chemistry of salt-affected soils and amendments; soil pH, EC_e, 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 and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (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.

Learning outcome

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

Course Title : Soil Mineralogy, Genesis and Classification

Course Code : Soil 504

Credit Hours : 2+1

Aim of the course

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 crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and

heavy metals.

Unit III

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

Unit IV

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

Practical:

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

Learning outcome

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

Course Title : Soil Erosion and Conservation

Course Code : Soil 505

Credit Hours : 2+1

Aim of the course

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

Unit VI

Watershed management - concept, objectives and approach; waterharvesting 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

Learning outcome

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

Course Title : Soil Biology and Biochemistry

Course Code : Soil 506

Credit Hours : 2+1

Aim of the course

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

Soilbiota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soilbiota.

Unit II

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

Unit III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and proteinaceous materials, cycles of important organic nutrients.

Unit IV

organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit V

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

Unit VI

Biofertilizers—definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

Unit VII

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

Practical:

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N₂ fixation, S oxidation, P solubilization and mineralization of other micronutrients.

Learning outcome

Experience on the knowledge of soil microbes and their utility in research for solving field problems in relation to soil management and crop production.

Course Title : Radioisotopes in Soil and Plant Studies

Course Code : Soil 507

Credit Hours : 1+1

Aim of the course

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 $^{32}\text{P}/^{65}\text{Zn}$
- Use of neutron probe for moisture determination
- Sample preparation and measurement of ^{15}N enrichment by mass spectrophotometry/ emission spectrometry

Learning outcome

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

Course Title : Soil, Water and Air Pollution

Course Code : Soil 508

Credit Hours : 2+1

Aim of the course

To make the student aware 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 effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit IV

Pesticides—their classification, behaviour in soil and effect on soil microorganisms.

Unit V

Toxic elements—their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases—carbon dioxide, methane and nitrous oxide.

Unit VII

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

Practical:

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO₂ and O₂ conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

Learning outcome

Management of soil and water pollution

Course Title : Remote Sensing and GIS Technique for Soil, Water and Crop Studies

Course Code : Soil 509

Credit Hours : 2+1

Aim of the course

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, 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 radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

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

Unit IV

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

Unit V

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

Practical:

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

Learning outcome

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

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

Course Code : Soil 510

Credit Hours : 0+2

Aim of the course

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:

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

Learning outcome

Development of confidence for setting soil testing laboratory.

Course Title : Management of Problem Soils and Water

Course Code : Soil 511

Credit Hours : 2+1

Aim of the course

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; salt stress meaning and its effect on crop growth, monitoring of soils alinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

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

Unit V

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

Unit VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality groundwaters.

Practical

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

Learning outcome

Experience on solving field problem of problem soil and waters.

Course Title : Land Degradation and Restoration

Course Code : Soil 512

Credit Hours : 1+0

Aim of the course

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

Theory:**Unit I**

Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit II

Land restoration and conservation techniques-erosion control, reclamation of salt- affected soils; mine land reclamation, afforestation, organic products.

Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Learning outcome

Experience on restoration of degraded soil for optimization of crop yield.

Course Title : Soil Survey and Land Use Planning

Course Code : Soil 513

Credit Hours : 2+0

Aim of the course

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; thematic soil maps, cartography, mapping units, 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 irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

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

Unit IV

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

Practical

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

Learning outcome:

Planning for land use in proper way for higher crop productivity

Course Title : Introduction to Nanotechnology

Course Code : Soil 514

Credit Hours : 2+1

Aim of the course

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 inorganic materials used for the synthesis of hybrid nano-bioassemblies, application of nano-in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

Practical:

- Sources of nanoparticles and 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.

Learning outcome:

Experience on the knowledge of nano science and their utility in research for solving fieldproblem.

Course Title : Biofertilizer Technology

Course Code : MICRO 511

Credit Hours : 2+1

Aim of the course

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

Theory:

Block 1: Agriculture Important Beneficial Microorganisms

Unit 1: Agriculturally important beneficial nitrogen fixing microorganisms.

Different agriculturally important beneficial microorganisms: Chemical Vs Biofertilizers: Current Scenario in biofertilizer technology in world-In India-List of biofertilizers-their applications in agriculture. Brief introduction about Agriculturally beneficial microorganisms (free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including phosphobacteria, cyanobacteria, their types and importance taxonomic classification, Nitrogen fixing biofertilizers: nodule formation, competitiveness and quantification of N₂ fixed and their use. Mechanism of phosphorous solubilization by photobacteria. BIS standards of biofertilizers

Unit 2: Agriculturally important beneficial microorganisms related to phosphorous, potassium,

Sulphur and Zinc nutrition

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

Unit 3: Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria.

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

Unit 4: Agriculturally important biocontrol microbial inoculants

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

Unit 5: Economics of biofertilizer production

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

Block 2: Production of Biofertilizer

Unit 1: Production and quality control of biofertilizer

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

Practical:

- Isolation of phosphate solubilizing microorganisms.
- Development and production of efficient microorganisms,
Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc,
- Bioinoculant production and quality control.
- Population dynamics in broth and carrier materials during storage.
- Development of cultures from starter.
- Preparation of broth for large scale cultivation in fermenter/ large containers. Inoculation and development of culture.
- Mass production of carrier based and liquid biofertilizers. Mass production of important two or three

biocontrol agents (Trichoderma viride, Pseudomonas fluorescens and Metarhiziumanisopliae).

- Form, dose and method of application.
- Mass production of AM fungi in pot and root organ culture.
- Quality control and BIS standards.
- Mass production of Azolla and BGA.
- Visit to a biofertilizer production plant

Learning outcome

After successful completion of this course, the students are expected to be able to learn:

- Agriculturally important beneficial microorganisms for fixation of various important elements and compounds.
- Biofertilizer production and usage at national and international levels and also create self employment.
- Requirements for establishing bioinoculants production unit, economics (solid liquid carrier) production, constraints in biofertilizers production and usage.
- A complete exposure to all kinds of agriculture important biofertilizers along with their functions and properties,
- Helps to develop as entrepreneur or employer.

Course Title: Soil Physical Environment and Plant Growth

Course Code: AP 510

Credit Hours: 2+1

Aim of the course

To impart knowledge about characterization and management of soil physical environment in relation to plant growth and yield.

Theory:

Unit I

Introduction: Effect of soil physical properties on plant growth - soil water, soil air, soil temperature, mechanical impedance and tillage practices.

Unit II

Soil water: Soil moisture – plant water relations, available water, newer concepts of water availability, least limiting water range, soil-plant-atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum.

Unit III

Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.

Unit IV

Soil Temperature – effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching, radiation – heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere.

Unit V

Aeration – critical oxygen concentration and factors affecting.

Unit VI

Field water balance – field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture

Unit VII

Nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, integrated nutrient management in relation to soil physical condition.

Unit VIII

Resource conservation technologies- bed planting & zero-tillage - types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term) on soil health.

Unit IX

Modelling: Interactions of soil, management and climatic factors on plant growth, development of sustainability indices.

Practical:

- Measurement of penetration resistance and LLWR, Plant water potential;
- Field saturated hydraulic conductivity, transpiration using Porometer;
- Root Length Density, Root Diameter, Root weight using Root Scanner, plant N content;
- Germination percentage as affected by temperature;
- Estimation of evapotranspiration losses, estimation of consumptive water use, production functions, field water balance components, water uptake by plants.

Learning outcome

Basic knowledge on soil physical environment to solve field problem

Course Title : Pesticide Residue Chemistry

Course Code : AC 510

Credit Hours : 2+1

Aim of the course

To teach the students extraction, cleanup, recovery and analysis techniques, develop and validate analytical methodology for risk assessment and MRL fixation.

Theory:

Block 1: Introduction to Pesticide Residue Chemistry

Unit 1: Pesticide Residue – Concept and Significance

Pesticide residue definition, source, Significance of Certified Reference Materials (CRMs) in pesticide residue analysis, Planning and layout of experiments, Good agricultural practices (GAP) and experimental design, Post-harvest interval (PHI)

Unit 2: Laboratory Data Documentation and Proficiency Testing

Documentation and audit of laboratory data, Inter laboratory comparison and laboratory proficiency testing, legal implications of pesticide residue data

Block 2: Analysis of Pesticide Residues

Unit 1: Extraction, Clean Up and Recovery

Sampling, sample processing and testing, Different extraction and clean up techniques for optimum recovery

Unit 2: Method Development and Validation

Method development, Validation and performance verification through linearity, sensitivity, matrix effect, limit of quantification (LOQ), limit of detection (LOD), accuracy and precision of recovery, Measurement uncertainty (MU)

Unit 3: Monitoring of Pesticide Residue

Monitoring of pesticide residue in agricultural produce and environment, Multiresidue analysis by quick, easy, cheap, effective, rapid and safe (QuEChERS) method, GC/LC, GC-MS, LC-MS method. ELISA and Radiotracer techniques in residue analysis.

Block 3: Consumer Risk Assessment and MRL Fixation

Unit 1: Consumer Risk Assessment

Hazard and risk, Ecological and human health risk assessment, Acceptable daily intake (ADI), theoretical maximum daily intake (TMDI), estimated daily intake, Maximum Residue Limit, No Observed Adverse Effect level (NOAEL), Food factor.

Unit 2: MRL fixation of Pesticides in Food Commodities

Safe waiting period, Lowest, highest and median residue data, OECD MRL Calculator, Significance of Codex, EU and FSSAI MRLs.

Practical:

- Collection, storage and preparation of samples for pesticide residue analysis
- Extraction and clean-up of food, soil and water sample prior to analysis of pesticide residues
- Study the percent recovery of pesticide residues from vegetable, soil, and/or water samples fortified with the standard pesticide analyte
 - Validation of analytical method by studying linearity, matrix effect, LOD, LOQ, accuracy (recovery) and precision as per SANTE guidelines
- Identification of organochlorine insecticides in soil and water by TLC/GC/HPLC
- Identification of Carbamate insecticides in water by TLC/GC/HPLC,
- Estimation of carbamate insecticide residues in vegetable by visible spectroscopic method and HPLC
- Estimation of OP insecticide residues in soil by spectroscopic method and HPLC.

Learning outcome

After successful completion of the course, student will acquire knowledge about the pesticide residue analysis, consumer risk assessment and MRL fixation in environmental safety point of view.

Course Title : Basic Biochemistry

Course Code : BIOCHEM 501

Credit Hours : 3+1

Aim of the course

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

Theory:**Block 1: Introduction to Biochemistry****Unit 1: Scope and importance of biochemistry (1 Lecture)**

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

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Unit 2: Foundation of life (2 Lectures)

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

Unit 3: Water (3 Lectures)

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

Unit 4: Physical techniques for structure determination (2 Lectures)

General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure and Function of Biomolecules

Unit 1: Biomolecules (10 Lectures)

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

Unit 2: Immunoglobulins and PR proteins (2 Lectures)

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

Unit 3: Plant secondary metabolites (3 Lectures)

Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (2 Lectures)

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

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures)

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit 1: Catabolism of energy molecules (5 Lectures)

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

Unit 2: ATP formation (3 Lectures)

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

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (4 Lectures)

Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (3 Lectures)

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

Practical:

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

Learning outcome

With this course, the students are expected to be able to understand the actual chemical concepts and fundamental processes of biology at molecular level.

Course Title : Techniques in Biochemistry

Course Code : BIOCHEM 505

Credit Hours : 2+2

Aim of the course

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

Theory:**Block 1: Separation Techniques**

Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures)

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

Unit 2: Electrophoretic technique (2 Lectures)

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

Unit 3: Hydrodynamic methods (2 Lectures)

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

Unit 4: Centrifugation (2 Lectures)

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

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures)

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

Unit 2: Mass spectroscopy (3 Lectures)

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

Unit 3: Atomic absorption spectrophotometry (2 Lectures)

Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures)

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

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures)

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

Unit 2: Imaging techniques (2 Lectures)

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

Unit 3: Immunochemical technique (2 Lectures)

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

Unit 4: Other techniques (2 Lectures)

Cryopreservation, polymerase chain reaction (PCR), FACS.

Practical:

- Expression of concentration in terms of dilution, molarity, normality, percent expression

- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
 - Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- $(\text{NH}_4)_2\text{SO}_4$ precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

Learning outcome

At the end of the course, the student will acquire the basic knowledge of the main biochemical methods used in the separation, identification, characterization and analysis of biomolecules.