New & Restructuring of
Post Graduate Curriculum & Syllabus
for
M.Sc. (Ag.)-Soil Sc. & Agri. Chem.
w.e.f. Session : 2019-20
Semester System
as per
Fifth Deans Committee Reoprt of ICAR

Submitted & Approved By-
Board of Studies
Faculty of Agriculture
Dr. Ram Manohar Lohia Avadh University
Ayodhya (U.P.) 224001
### ISt Semester

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<th>Practical</th>
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<tbody>
<tr>
<td>SSAC - 504</td>
<td>Soil Mineralogy, Genesis, Classification &amp; Survey</td>
<td>3(2+1)</td>
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<td>SSAC - 509</td>
<td>Soil, Water and Air Pollution</td>
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<td>SSAC - 511</td>
<td>Analytical Techniques &amp; Instrumental Methods in Soil and Plant Analysis</td>
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### IIInd Semester

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<td>SSAC - 501</td>
<td>Soil Physics</td>
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<td>Soil Fertility and Fertilizer Use</td>
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<td>Soil Chemistry</td>
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<td>Soil Biology &amp; Biochemistry</td>
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<td>SSAC - 505</td>
<td>Soil Erosion and conservation</td>
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<td>SSAC - 510</td>
<td>Remote Sensing &amp; GIS Techniques for Soil, Water and Crop Studies</td>
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<td>Advanced Bio-pesticides &amp; Bio-Fertilizers</td>
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<td>Reclamation &amp; Management of Waste Land and Other Problematic Soils</td>
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<tr>
<td>SSAC - 517</td>
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<td>Advanced Agricultural Microbiology</td>
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SOIL SCIENCE & AGRICULTURAL CHEMISTRY

Course Contents

SSAC 501  SOIL PHYSICS  3Crs. (2+1)

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

Theory,

UNIT I
Scope of soil physics and its relation with other branches of soil science; soil as a three phase system.

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

UNIT III
Soil consistency; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.

UNIT IV
Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil ceasing - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties: clogged 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 IX
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 X
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
- Mechanical analysis by pipette and international methods
- 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

SSAC 502  SOIL, FERTILITY AND FERTILIZER USE, 4 Crs. (3+1)

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; nutrient sources — fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.

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 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.

UNIT IV
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; 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; blanket fertilizer recommendations — usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management.

UNIT IX
Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical
- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for total and available nutrients
chemistry of acid soils; sub-soil acidity.

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

UNIT VIII
- Chemistry and electrochemistry of submerged soils.

Practical
- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, Eo by the use of Eo-pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Potentiometric and conductometric titration of soil humic and fulvic acids
- (Eo/Eo) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the A (Eo/Eo) 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 lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

SSAC 304 SOIL MINERALOGY, GENESIS, CLASSIFICATION 3 Crs. (2+1)
AND SURVEY

Objective
To acquaint students with basic structure of aluminosilicate 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 results in terms of land use planning.

Theory
UNIT I
- Fundamentals of crystallography, space lattice, coordination theory, isomorphism...
Analysis of plants for essential elements

SSAC 503  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.

UNIT I
Chemical (elemental) composition of the earth's crust and soils.

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; clay-organic interactions.

UNIT IV
Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, ionic activity measurement, thermodynamics, anion and ligand exchange - inner-sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V
Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.

UNIT VI
Chemistry of acid soils: active and potential acidity; lime potential.
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
Concepts and definitions of soil, soil profile; Formation and weathering of rocks and mineral, weathering sequences of minerals. Factors of soil formation, soil forming processes.

UNIT IV
Concept of soil individual; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy; application of soil taxonomy.

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.

UNIT VI
Landform - soil relationship; major soil groups of India and UP.; land capability and 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
- Land use planning exercises using conventional and RS tools.
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 Elm) index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

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

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

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

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

Practical

- Determination of different soil erodibility indices, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Visits to a watersheds

SSAC 506  
SOIL BIOLOGY AND BIOCHEMISTRY  
3 Crs. (2+1)

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; unicellular 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; basic principles of humus formation.

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

SSAC 509

SOIL, WATER AND AIR POLLUTION

3 Crs. (2/-1)

Objective
To make the students 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, behavior in soil and effect on soil microorganisms.

UNIT V
Toxic elements — their sources, behavior 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 VIII
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
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents
- Heavy metals and pesticides in contaminated soils and plants
- Management of contaminants in soil and plants to safeguard food safety
- Air sampling and determination of particulate matter and oxides of sulphur
- Visit to various industrial sites to study the impact of pollutants on soil and plants

SSAC 510 REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES

Objective

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.

UNIT II

Sensor systems - camera, microwavemeters and scanners; fundamentals of aerial photographs and image processing and interpretations.

UNIT III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland 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
Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical
- Familiarization with different remote sensing equipments and data products
- Interpretation of aerial photographs and satellite data for mapping of land resources
- Analysis of variability of different soil properties with classical and geo-statistical techniques
- Creation of data files in a database programme
- Use of GIS for soil spatial simulation and analysis
- To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

SSAC511 ANALYTICAL TECHNIQUES 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

UNIT I
Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexometric titrations; soil, water and plant sampling techniques, their processing and handling.

UNIT II
Principles of visible, ultraviolet 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.
UNIT III
Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

SSAC513 MANAGEMENT OF PROBLEM SOILS AND WATERS  3 Crs. (2+1)

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 and sodic soils; origin 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; characterization of brackish waters; 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⁺, Ca²⁺ and Mg²⁺) in ground water and soil samples
- Determination of anions (Cl⁻, SO₄²⁻, CO₃⁻ and HCO₃⁻) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils
UNIT - 1
Classification, tabulation and graphical representation of data. Box-plot. Descriptive statistics, Exploratory data analysis; Theory of probability, Random variable and mathematical expectation.

UNIT - 2
Discrete and continuous probability distribution: Binomial, Poisson, Normal distribution. 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 - 3
Introduction to theory of estimation and confidence-intervals, correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted value and residuals, correlation coefficient, partial, correlation coefficient, multiple correlation coefficient, rank correlation coefficient, test of significance of correlation coefficient and regression coefficient, coefficient of determination.

UNIT - 4
Need for designing of experiments, characteristics of a good design, Basic principles of designs, randomization, replication and local control.

UNIT - 5
Uniformity trials, size and shape of plots and blocks, analysis of variance, completely randomized design, randomized block design and Latin square design, missing plot techniques, split plot design.

UNIT - 6
Sampling Techniques - Planning of survey, method of data collection, questionnaire v/s schedule, Problems of sampling frame choice of sample of design, probability sampling, sample space, sampling design, simple random sampling. Estimation of proportion, confidence interval. Determination of sample size, stratified sampling, cluster sampling, multi state sampling, systematic sampling, ratio and regression methods of estimation, Non sampling error, source and classification.

Practical

- Related with the course
CA - 502 COMPUTER APPLICATION IN AGRICULTURE 2 (1+1)

Introduction to computer, operating system, definition and types, application of MS-Office for document creation & Editing. Data presentation, interpretation and graph creation, statistical analysis, mathematical expressions, database concepts and types; uses of DBMS in Agriculture, World Wide Web (WWW); Concepts and components. Introduction in computer programming languages, concepts and standard input/output operations.

e-Agriculture concepts and applications, Use of JCT in Agriculture. Computer models for understanding plant processes. IT Application for computation of water and nutrient requirement of crops, computer-controlled devices (automated system) for agri-input management, Smart phone Apps in Agriculture for farm advises market price, post harvest management etc; Geospatial technology for generating valuable agri-information. Decision support systems, concepts, components and applications in agriculture, agriculture expert system, Soil information system etc. for supporting farm decisions. preperation of contingent crop-planning using IT tools.

Practical

Study of computer components, accessories, practice of important DOS Commands. Introduction of different operating system such as window, Unix/Linux, Creating, Files & Folders, File Management. Use of MS-Word and MS Power-point for creating, editing and presenting a scientific document. MS-Excel - Creating a spreadsheet, use fo statistical tools, writing expressions, creating graphs, analysis of scientific data. MS-Access - Creating database, preparing queries and reports, demonstration of agri-information system. Introduction to World Wide Web (WWW). Introduction of Programming languages. Hands on Crop Simulation Models (CSM) such as DSSAT/Crop-Info/Crop Syst/Wofost; Computation of water and nutrient requirements of crop using CSM and IT tools. Introduction of Geospatial Technology for generating valuable information for Agriculture. Hands on Decision Support system. Preparation of contingent crop planning.
SSAC - 514 Advanced Organic Chemistry & Plant Biochemistry 4 (3+1)

 Characteristics of chemical bonds and covalency, classification of organic compounds. Nomenclature and their general properties. Chemistry of functional groups, chemistry of aromatic compounds (Benzene & Phenol). Heterocyclic compounds (Pyridines & Pyrimidines) organic reaction substitution, elimination & addition.

 General Chemistry of carbohydrates and photosynthesis of carbohydrates. General Chemistry of lipids, amino acids, nucleic acids, plant pigments, alkaloids, plant hormones their chemistry & uses. Vitamins, classification and occurrence, chemistry and deficiency symptoms. General chemistry of proteins & their biosynthesis, their classification, mechanism of their activity.

 Practical - Related with course.

SSAC - 515 Advanced Bio-pesticides & Bio-Fertilizers 4 (3+1)

 Theory


 Impediments and limitation in production and use of biopesticides.

 Biofertilizers - Introduction, status and scope, structure and characteristic features of bacterial biofertilizers. Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia.


 Production technology: Strain selection, sterilization growth and fermentation, mass production of carrier based and liquid biofertilizers. FCQ specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers, sets etc. Biofertilizers - storage, self life, quality control and marketing factors influencing the efficacy of biofertilizers.

 Practical

 Isolation and purification of important biopesticides, Trichoderma Pseudomonas, Bacillus, Methylobium etc. and its production. Identification of important botanicals. Visit to biopesticide laboratory in nearby area. Field visit to explore naturally infected eadviers. Identification of entomopathogenic entities in field condition. Quality control of biopesticides.

SSAC - 516 Reclamation & Management of Waste Land and Other Problematic Soils
4 (3+1)

Theory

Classification and characteristics of waste lands, Management of acid-soils, salt-affected soils, clay lands, organic soils (Histosol); Formation, Classification of Organic soils, Characteristics of organic soils, Management of organic soils. Soils distributed by constitutional activities.

Water-logged soils and their type, factors affecting, formation of water-logged soils, characteristics of wet land soils, constraints associated with excess of water, management of water-logged soils. Rice/paddy soils, clay soils. Acid sulphate soils: Definition; Classification and characteristics of acid sulphate soils, formation, reactions involving in the formation of acid sulphate soils, management of acid sulphate soils. Sandy soils and eroded soils.

Practical: Related with course.

SSAC - 517 Agricultural Biochemistry 4 (3+1)

Theory

Composition of animal body and its food, importance of carbohydrates, proteins, fats, mineral matter & vitamins in animal nutrition. The process of digestion and absorption in animal body.


Adulteration of milk and ghee, use of various adulterants and their detection.

Preparation, composition and properties of milk products viz. butter, cream, ghee, evaporated milk and milk powder. Enzyme: their occurrence, properties and mode of enzymatic action.

Practical: Related with course.

SSAC - 518 Advanced Agricultural Microbiology 4 (3+1)

Introduction of Microbial world: Prokaryotic and eukaryotic microbes. Bacteria cell structure, Chemocautrophy, photo autotrophy, growth. Bacterial genetics, Genetic recombination, transformation, conjugation and transduction, plasmids, transposable.


Practical