Ph. D. Syllabus in the Department of Soil Science & Agricultural Chemistry

Course code	Course title	Credit
SSC 600	Research methodology and techniques	4 +0
ACH 601	Advances in chemistry of pesticides	4 +0
SSC 601	Advances in soil physics	4 +0
SSC 602	Advances in soil fertility	4 +0
SSC 603	Advances in soil chemistry	4 +0
SSC 604	Advances in soil biology and biochemistry	4 +0

SSC 600 Research methodology and techniques 4+0

Objective:

The students are expected to gain knowledge on different aspects of research methodology and techniques like objectives, types, approaches of research, design of experiments, precaution and safety measures to be taken in laboratory, working principle of different instruments like Absorption Spectroscopy, pH meter etc. and principle of chromatography etc.

Syllabus:

Research - Meaning, objectives, types, approaches, selection of problems, design. Laboratory hygiene and safety, laboratory accidents and their management. Human safety and protection, handling and storage of flammable, volatile, health hazardous and corrosive chemicals, glassware safety, emergency response. Precaution and safety while carrying out reactions and reaction wastes. Hydrodistillation, steam distillation, supercritical fluid extraction, extraction of volatile substances by Clevenger apparatus and solid phase extraction. Theory, principle and instrumentation of different Absorption Spectroscopy, such as, UV, Visible, IR and Atomic Absorption Spectrophotometry, pH meter. Separation science and technology : Paper, column, thin layer chromatography, ion exchange and flash chromatography, principle, adsorbents, their separation properties, mechanism of relation and application in isolation of different compounds and elements. Introduction to laboratory equipments and cleaning of glasswares, purification of solvents, crystallization, identification and sublimation. Extraction chromatography : paper, TLC, column, ion-exchange. Steam distillation, elemental analysis, practical use of Stirrer, pump, shaker and presentation, determination of pH of samples by pH Meter, preparation of buffer solution.

Learning Outcome:

Students will acquire detailed knowledge on research methodology and techniques.

ACH 601 Advances in chemistry of pesticides 4+0

Objective:

The students are expected to gain detailed and in-depth and advanced knowledge on classification, formulation, movement, fate, persistence, transformation, chemistry, mode of action of various pesticides, fungicides, nematicides etc.

Syllabus:

General aspects – definition, objectives, process, product spectrum, classification, formulation codes etc. Solid and liquid formulations including the latest developments – preparation, properties, specification, use situation etc. Formulants – carrier / diluents, surfactants, synergists, safeners, encapsulants, antioxidents, stabilizers etc. highlighting chemistry, classifications, properties, uses etc. formulation – toxicant interaction, pesticides mixture. Machinery and equipments, packaging and labelling, decontamination etc. Precaution in use of pesticides, bio-efficacy – basic consideration and applied aspects, physico-chemical basis pesticide antidotes. Movement and fate of pesticides in the environment : Drift, volatilization, adsorption, disorption, leaching, run-off etc. Soil-pesticide interactions movement and plant, animal and other living systems : penetration, transformation, excretion etc. (Highlight the role of physico-chemical parameters). Persistence - factors affecting (physical, chemical, biochemical etc.), primary and secondary metabolites in plans and animals with examples. Biotic and abiotic transformation, bio-chemical transformation in living systems. Photochemical transformation of pesticides : Introduction to photochemistry, direct and indirect photolysis, photosensitisers, quenchers, light filters, quantum yield. Phototransformation products and their significance, other abiotic factors transforming xenobiotics. Chemical transformation of xenobiotics – effect of pH, eH, moisture, environmental gases etc. Conventional natural insect control agents such as pyrethroids, rotenones, nicotine, ryanodine, isobutyl acides, drimane, sesquiterpenoids, withanolides, clerodanes, quassinoids and limonoids – sources, isolation, characterization, synthesis, application and mode of action. Insect behaviour modifying chemicals (semiochemicals) – pheromorus (sex, alarm, trail, territorial, aggregation etc.), Allelochemicals – allomones, kairomeones, synomones, apheumones. Insect hormones – JH (Juvenile Hormone) anti-JH, JH-mimics, feeding deterrents and repellents – both natural and synthetic : source, chemistry, mode of action etc. Chemistry, use and mode of action of natural fungicides, nematicides including photoactivated pesticides like α - terthieyl. Pesticides of tetraractin, avermectins, milbinycins and spinosad. Herbicides like biolaphos and phosphonothricin, phytotoxins like Alternaria alternate toxin, tentoxin, cornexistin, hydantoxidin. Allelochemicals and chemical ecology, application of biotechnology in pest management (ex Bt). Extraction by hydrodistillation, isolation of pure compounds, their characterization, extaction of tobacco leaves, isolation of nicotine and its identification, extraction of neem seed kernels, enrichment of azadiractin, analysis of azadiractin and its analysis. Preparation of metabolites, photodegradation of pesticides, leaching of pesticides, biological degradation in soil.

Learning Outcome:

Students will acquire detailed knowledge on different aspects of pesticides chemistry.

SSC 601 Advances in soil physics 4+0

Objective:

The students are expected to gain in-depth and advanced knowledge or modern concept on different aspects of soil physics like soil water potential, free energy and thermodynamics, fluid flow, Poiseuilles law, Darcy's law, theories of infiltration, mass flow and diffusion of soil air, thermal properties of soil, soil crust, soil conditioners, evapotranspiration, Atterberg limits. Aggregate analysis, soil-moisture characteristic curve, hydraulic conductivity and so on.

Syllabus:

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system. Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow. Theories of horizontal and vertical infiltration under different boundary conditions. Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves. Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil. Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in agriculture. Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer. 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 characteristic 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:

Students will acquire detailed and advanced knowledge on different aspects of soil physics.

SSC 602 **Advances in soil fertility** **4+0**

Objective:

The students are expected to gain in-depth and advanced knowledge or modern concept on different aspects of soil fertility like nutrient availability, nutrient response functions and availability indices, nutrient movement in soils, nutrient absorption by plants, chemical equilibria involving nutrient ions in soils, nutrient use efficiency and nutrient budgeting, fertilizer application; soil fertility evaluation techniques, long-term fertilizer experiments, soil and plant analysis etc.

Syllabus:

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices. Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils. Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils. Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting. Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture. Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use. Extraction and determination of available plant nutrients in soil. Soil fertility evaluation by chemical and biological methods. Analysis of plants for essential elements.

Learning Outcome:

Students will acquire detailed and advanced knowledge on modern concepts of soil fertility.

SSC 603 **Advances in soil chemistry** **4+0**

Objective:

The students are expected to gain in-depth and advanced knowledge on different aspects of soil chemistry like colloidal chemistry, clay organic interaction, clay minerals, cation exchange equilibria - thermodynamics, diffuse double layer theory (DDL), thermodynamics of nutrient transformations in soils, cationic and anionic exchange and their models, adsorption/desorption isotherms, solubility equilibria, chemistry of acid soils and salt affected soils etc.

Syllabus:

Colloidal chemistry of inorganic and organic components of soils – their formation, clay organic interaction. 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. Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer. Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction. Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system). Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use). Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. 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. 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 Ä (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 lime requirement of an acid soil by buffer method. Determination of gypsum requirement of an alkali soil

Learning Outcome:

Students will acquire detailed and advanced knowledge on different modern concepts of soil chemistry.

SSC 604 Advances in soil biology and biochemistry 4+0

Objective:

The students are expected to gain in-depth and advanced knowledge on different aspects of soil biology and biochemistry like soil microbial ecology, soil microbial biomass, microbial interactions, phyllosphere, soil enzymes, microbial transformations of soil nutrients, soil organic matter, biodegradation of pesticides, manures, biofertilizers, soil microbial processes etc.

Syllabus:

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. 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. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, classification, specifications, method of production and role in crop production. 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.

Learning Outcome:

Students will acquire detailed and advanced knowledge on different modern concept of soil biology and biochemistry.