23 Soil Science and Agricultural Chemistry

TRIMESTER WISE DISTRIBUTION OF COURSES

I TRIMESTER

		L	P
AGR 004	SOILS AND ENVIRONMENT	2	1
SSAC 501	QUANTITATIVE INORGANIC ANALYSIS	3	2
SSAC 503/ AP 503	FUNDAMENTALS OF SOIL PHYSICS	3	1
SSAC 504	SOIL CHEMISTRY	4	1
SSAC 509	RADIO TRACER TECHNIQUES IN SOIL AND PLANT STUDIES	3	1
SSAC 510/ AG 510/ WST 510	MANAGEMENT OF PROBLEM SOILS AND WATERS	3	1
SSAC 603	NUTRIENTS IN SOILS AND PLANTS	3	0
SSAC 605	SOIL RESOURCE MANAGEMENT	3	0
SSAC 691	SEMINAR	1	0

II TRIMESTER

SSAC 505/ AP 505	SOIL GENESIS, CLASSIFICATION AND SURVEY	2	2
SSAC 506	SOIL BIOLOGY AND BIOCHEMISTRY	4	1
SSAC 508	MANURES, FERTILIZERS AND BIOFERTILIZERS	3	2
SSAC 601	SOIL CLAYS AND CLAY MINERALOGY	3	1
SSAC 602	SOIL CHEMICAL ENVIRONMENT AND PLANT GROWTH	3	2
SSAC 604/ ES 604	SOIL ORGANIC MATTER	3	0
SSAC 606/ ES 606	SOIL AND WATER POLLUTION	2	1
SSAC 691	SEMINAR	1	0

III TRIMESTER

SSAC 502/ AG 502/ AP 502	SOIL FERTILITY AND NUTRIENT MANAGEMENT	3	1

SSAC 507	SOIL TESTING, WATER QUALITY AND FERTILIZER RECOMMENDATIONS	3	2
SSAC 607	MODELING SOIL PLANT SYSTEM	3	1
SSAC 611/ AP 611	SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH	3	1
SSAC 691	SEMINAR	1	0

Core Courses

M.Sc.: SSAC 501, SSAC 502, SSAC 503, SSAC 504, SSAC 505, SSAC 506

Ph.D.: SSAC 601, SSAC 602, SSAC 603, SSAC 605

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Major Fields : Soil Science

Agricultural Chemistry

(For M.Sc. students: Soil Science and Agricultural Chemistry)

Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 004 SOILS AND ENVIRONMENT **(2L + 1P) I**

Objective

To impart fundamental knowledge on soil as a natural entity and its management for crop production

Theory

UNIT I

Soil as a natural body and medium for plant growth; nature and origin of soil, soil formation, classification and survey.

UNIT II

Composition of rocks, minerals and soils; soil properties – physical, chemical and biological; soil-water-plant relations.

UNIT III

Essential plant nutrients, their functions and symptoms of deficiencies; soil fertility and productivity; techniques of soil fertility evaluation; soil testing and fertilizer recommendations; manures, fertilizers and amendments.

UNIT IV

Soil organic matter; enhancing potential of agricultural soils for carbon sequestration; role of soils in carbon cycling; soil nutrient mining and land degradation; soil management and climate change.

UNIT V

Soil erosion, and soil and water conservation; problem soils - nature and management of acidic, salt-affected and waterlogged soils; soils of India.

Practicals

Soil sampling and processing; determination of water holding capacity of soil, pH, electrical conductivity, soil organic carbon, mineralizable N in soil; determination of available P, K and micronutrients in soil; lime requirement of acid soils and gypsum requirement of sodic soils; soil-test based fertilizer recommendations

Suggested Readings

Black, C.A. 1993. *Soil Fertility Evaluation and Control*. Lewis Publishers, Boca Raton, USA.

Brady, N.C. and Weil, R.R. 2002. *The Nature and Properties of Soils.* 13th Edition. Pearson Publication, New Delhi.

Dhyan Singh, Chhonkar, P.K. and Dwivedi, B.S. 2005. *Manual on Soil, Plant and Water Analysis*, Westville Publishing House, New Delhi

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson W.L. 2006. *Soil Fertility and Fertilizers*: *An Introduction to Nutrient Management.* 7th Edition. Prentice Hall, New Delhi.

Richards, L.A. 1954. *Diagnosis and Improvement of Saline – Alkali Soils.* USDA Handbook **60**.

Sehgal, J.L. 2002. *Pedology – Concepts and Applications*. Kalyani Publishers, Ludhiana.

SSAC 501 QUANTITATIVE INORGANIC ANALYSIS (3L+2P) I

Objective

To impart the basic knowledge to the students on principles of inorganic analysis including use of instruments in soil, plant and water research and develop their skills as the quality analysts through sustained practical exercises

Theory

UNIT I

Introduction and scope of the course; principles of chemical analyses; ionic equilibria, ionic product, hydrolysis, solubility product.

UNIT II

Fusion and digestion of soil and plant samples including wet digestion and dry-ashing.

UNIT III

Volumetric analysis: Principles of volumetric analysis; neutralization reactions, complex formation reactions, precipitation reactions and oxidation-reduction reactions; indicators and theory of indicators.

UNIT IV

Gravimetric analysis: Formation and properties of precipitates; washing of precipitates; co-precipitation and post-precipitation; conditions of precipitation.

UNIT V

Principles of potentiometry; Beer-Lambert's law; colorimetry, turbidimetry and spectrophotometry.

UNIT VI

Emission and absorption spectroscopy: Principles of flame photometry, atomic absorption spectroscopy and inductively coupled plasma atomic emission spectroscopy.

UNIT VII

Errors in quantitative inorganic analysis.

Practicals

Preparation of primary and secondary standard solutions; wet digestion/ fusion of soil for elemental analysis; tri-acid/di-acid digestion of plant samples; estimation of chloride by Mohr and Volhard's titration; organic carbon by Walkley and Black method; nitrogen in soil: total, ammoniacal, nitrate and available N, plant-N content by Kjeldahl method; volumetric and colorimetric estimation of P in soil, plant and water; estimation of zinc, iron, copper and manganese in soils and plants by colorimetry and atomic absorption spectrometry; potassium estimation by flame photometery; CO_3^{2-}, HCO_3^- and RSC in irrigation water; Ca by Ca-oxalate titration; S in soils and plants by turbidimetric and $BaCrO_4$ precipitation–yellow colour methods; Ca and Mg by versenate titration method; boron by azomethine-H method

Suggested Readings

Hesse, P. 971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons, Lahore.

Jackson, M.L. 1967. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.

Page, A.L., Miller, R.H. and Keeney, D.R. 1982. *Methods of Soil Analysis*. **Part II**. SSSA, Madison, Wisconsin.

Singh, D., Chhonkar, P.K. and Pandey, R.N. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.

Smith, Keith A 1991. *Soil Analysis: Modern Instrumental Techniques*. Marcel Dekker, New York.

Tan, Kim H. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press -Taylor and Francis, Boca Raton.

Tandon, H.L.S. 1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers. FDCO, New Delhi.

Vogel A.I. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman, London..

Willard, H.H, Merritt Jr, L.L., Dean, J.A. and Settle Jr., F.A. 1986. *Instrumental Methods of Analysis*. Second Edition. CBS, New Delhi.

SSAC 502/ AG 502/ AP 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT (3L+1P) III

Objective

To teach basics of soil fertility evaluation, techniques of soil fertility evaluation, plant nutrients, integrated approach of plant nutrition, and environmental quality.

Theory

UNIT I

Historical aspects of soil fertility, essential plant nutrients: criteria of essentiality, classification, functions, deficiency and toxicity symptoms, beneficial elements.

UNIT II

Carbon cycle in nature, carbon stocks, sequestration, greenhouse effects, different carbon pools in soil and their role in maintaining soil quality and productivity; soil organisms and their role in soil fertility.

UNIT III

Transformations and dynamics of major- and micro-nutrients in soils and their availability to plants.

UNIT IV

Nutrient interactions in soils and plants: concept, different types of interaction, interaction among essential plant nutrients, law of minimum and maximum.

UNIT V

Commercial fertilizers, new fertilizer materials and principles of their evaluation, crop response to fertilizer application and use efficiency, economics of fertilizer use, nutrient requirements of crops and cropping systems in sustainable agriculture and quality of the produce, foliar nutrition of crop plants.

UNIT VI

Soil fertility evaluation: different approaches, soil and plant tests, biological tests, hidden hunger, critical nutrient concentration - concept and determination (graphical and statistical procedures), critical nutrient range, diagnosis recommendation and integrated system (DRIS)

UNIT VII

Integrated nutrient management (INM): concept, objectives and components; organic farming: principles, practices and its impact on soil processes; precision farming: concept and practices; organic manures including compost, farmyard manure, green manure and crop residues.

UNIT VIII

Fertilizer x water interactions, crop production under fertilizer / water constraints; site-specific nutrient management: concept and practices; summary of long-term fertilizer experiments.

Practicals

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 micronutrients); analysis of plants for essential elements (major and micronutrients)

Suggested Readings

Brady, N.C. and Weil, R.R 2002. *The Nature and Properties of Soils.* 13th Edition. Pearson Education, New Delhi.

Epstein, E. and Bloom, A. 2005. *Mineral Nutrition of Plants: Principles and Perspectives*. Second Edition. Sinauer Associates.

Fageria, N.K., Baligar, V.C. and Jones, C.A. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker, New York.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson W.L. 2006. *Soil Fertility and Fertilizers: An Introduction to Nutrient management.* 7th Edition. Prentice Hall, New Delhi.

Khasawneh, F.E., Sample, E.C. and Kamprath, E.J. (Editors) 1980. *The Role of Phosphorus in Agriculture*. Soil Science Society of America, Madison, Wisconsin, USA.

Marschner, H. 1995. *Mineral Nutrition of Higher Plants.* Second Edition. Academic Press, London.

Mortvedt, J.J., Cox, F.R., Shuman, L.M. and Welch, R.M. (Editors) 1991. *Micronutrients in Agriculture.* Second Edition. Soil Science Society of America, Madison, Wisconsin, USA.

Pierzynski, G.W., Sims, J.T. and Vance, G.F. 2002. *Soils and Environmental Quality,* Second Edition. CRC Press, Boca Raton.

Prasad, R and Power, J.F. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press, Boca Raton.

Srivastava, P.C. and Gupta, U.C. 1996. *Trace Elements in Crop Production*. Oxford and IBH, New Delhi.

Stevenson, F.J. (Editor) 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison, Wisconsin, USA.

Stevenson, F.J. 1986. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulfur and Micronutrients.* John Wiley and Sons, New York.

Sumner, A.M.E. (Editor) 2000. *Handbook of Soil Science*. CRC Press, Boca Raton, USA.

Tandon, H.L.S. (Editor) 1995. *Management of Nutrient Interactions in Agriculture*. FDCO, New Delhi.

SSAC 503/ AP 503 FUNDAMENTALS OF SOIL PHYSICS (3L+1P) I

Objective

To impart knowledge about physics and physical properties of soil and their role in its management

Theory

UNIT I

Basic principles of physics applied to soils *viz*. viscosity, surface tension, capillarity, stress-strain relations, gaseous diffusion, heat transport, thermodynamic principles; properties of water in relation to porous media.

UNIT II

Physical characterization of soil; soil as a polyphase system; mass-volume relationships.

UNIT III

Particle size distribution; soil texture; mechanical analysis; specific surface; clay - a colloidal surface; hydration of clays.

UNIT IV

Soil structure and aggregation: genesis, classification and evaluation; soil structural stability and indices; soil tilth; soil conditioners.

UNIT V

Geometry of pore space and pore size distribution; inter- and intra-aggregate pores; soil consistency and its limits; consistency and deformation of cohesive soils; compaction and crusting in soils; soil strength and its measurement.

UNIT VI

Geometry of water phase; energy state of soil water; water content and potential and their measurement; different components of soil water potential; soil water characteristics, hysteresis and available water.

UNIT VII

Flow of water in soil; Darcy's law, hydraulic conductivity and water diffusivity; saturated and unsaturated flow and equations; methods for saturated and unsaturated hydraulic conductivity measurement - both *in situ* and in laboratory; capillary movement of water, contact angle.

UNIT VIII

Entry of water into soil and its redistribution; permeability; evaporation from bare soil; modification of soil surface affecting infiltration and evaporation; field water balance.

UNIT IX

Gaseous phase in soil, content and composition; renewal of soil air and gaseous diffusion; measurement of soil aeration; factors affecting soil aeration.

UNIT X

Energy balance in bare soil; soil heat flux, heat capacity, specific heat and thermal diffusivity; soil temperature and its measurement, factors affecting; thermal regime in soil profile.

Practicals

Particle size analysis of soil; determination of bulk density, particle density and mass-volume relationships of soil; soil aggregate analysis; measurement of soil moisture content and soil moisture potential; determination of soil-moisture characteristic curve, saturated and unsaturated hydraulic conductivity, and infiltration characteristics of soil; determination of Atterberg constants; measurement of soil strength and soil temperature.

Suggested Readings

Baruah, T.C. and Barthakur, H.P. 2001. *Textbook of Soil Analysis*. Vikas Publishing House Pvt. Ltd, New Delhi.

Ghildyal, B.P. and Tripathi, R.P. 1987. *Soil Physics*. Wiley Eastern and New Age International, New Delhi.

Hillel, D. 1980. *Applications of Soil Physics*. Academic Press, New York.

Hillel, D. 1998. *Environmental Physics*, Academic Press, New York.

Jury, W.A., Gardner, W. and Horton, R. 2004. *Soil Physics*. John Wiley and Sons, New York.

Klute A. (Edited) 2006. *Methods of Soil Analysis*. **Part 1**. *Physical and Minerological Methods* (SSSA Book Series No. 5), ASA and SSSA, Madison, Wisconsin.

Lal, R. and Shukla, M.K. 2004. *Principles of Soil Physics*, Marcel Dekker, New York.

Warwick, A.W. (Edited) 2002. *Soil Physics Companion*, CRC Press, Boca Raton.

SSAC 504 SOIL CHEMISTRY (4L+1P) I

Objective

To impart basic knowledge on fundamentals of soil chemistry and chemistry of the soil, clay mineralogy, ionic equilibria, chemical processes and mechanisms of the soil constituents in relation to basic soil functions

Theory

UNIT I

Chemical composition of earth crust, soils, rocks and minerals.

UNIT II

Chemical bonding, chemical equilibria, chemical kinetics and thermodynamics.

UNIT III

Pauling's rule, silicate structure, crystalline oxides and amorphous materials; XRD analysis, stability and weathering of minerals; clay mineral transformation and synthesis.

UNIT IV

Soil colloids: Inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-change 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.

UNIT V

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, clay-membrane electrodes and ionic activity measurement; 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; soil solution; potassium dynamics, quantity-intensity relationships.

UNIT VI

Soil acidity - formation and properties of acid and acid sulphate soils; salt-affected soils - formation and properties.

UNIT VII

Organic matter – extraction, fractionation and characterization; interaction of organic matter with clay minerals and metals ions.

UNIT VIII

Phosphate chemistry in soil; geochemistry of micronutrients; chemical speciation; chemistry of waterlogged soils; environmental soil chemistry.

Practicals

Preparation of saturation extract; measurement of EC, pH, CO_3, HCO_3, Ca, Mg, K and Na concentration in saturation extract; calculation of minimum radius ratio of polyhedra and making models of silicate structure; quantity-intensity relationships of potassium in soil; extraction of humic substances; determination of lime potential and phosphate potential, zero-point charge of soil and redox-potential of submerged soils; calcium–potassium exchange equilibria in soil.

Suggested Readings

Bear, F.E. 1964. *Chemistry of the Soil.* Oxford and IBH, New Delhi.

Bolt, G.H. and Bruggenwert, M.G.M. 1978. *Soil Chemistry*, Elsevier, Asmsterdam, The Netherlands.

Greenland, D.J. and Hayes, M.H.B. 1978. *Chemistry of Soil Constituents*. John Wiley and Sons, New York.

Greenland, D.J. and Hayes, M.H.B. 1981. *Chemistry of Soil Processes*. John Wiley and Sons, New York.

McBride, M.B. 1994. *Environmental Chemistry of Soils.* Oxford University Press, New York.

Sposito, G. 1981. *The Thermodynamics of Soil Solutions*. Oxford University Press, New York.

Sposito, G. 1984. *The Surface Chemistry of Soils*. Oxford University Press, New York.

Sposito, G. 1989. *The Chemistry of Soils*. Oxford University Press, New York.

Stevenson, F.J. 1994. *Humus Chemistry*. Second Edition. John Wiley and Sons, New York.

van Olphan, H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley and Sons, New York.

SSAC 505/ AP 505 SOIL GENESIS, CLASSIFICATION AND SURVEY (2L+2P) II

Objective

To teach the students concept of pedon, Pedology as a core discipline of Soil Science, factors and processes of soil formation, soil classifications systems, survey and cartography. Main emphasis is on enabling the students to conduct soil survey and interpret soil survey reports for sustainable land use and planning.

Theory

UNIT I

Historical developments in Pedology; characterization and classification of rocks and minerals; weathering of rocks and minerals, weathering sequences of minerals with special reference to Indian soils; soil forming processes and factors of soil formation.

UNIT II

Concept of soil as an individual entity; soil classification – principles and historical development; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy.

UNIT III

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps; landform – soil relationships; application of remote sensing and GIS in soil survey and mapping; major soil groups of India.

UNIT IV

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-ecosystems.

Practicals

Morphological properties of soil profile in different landforms; classification of soils using soil taxonomy; calculation of weathering indices and its application in soil formation; grouping soils using available data base in terms of soil quality; aerial photo and satellite data interpretation for soil and land use; cartographic techniques for preparation of base maps and thematic maps; processing of field sheets, compilation and abstraction of maps in different scales

Suggested Readings

Boul, S.W., Hole, R.D., McCracken, R.J. and Southard, R.J. 1997. *Soil Genesis and Classification.* Iowa State University Press, Ames, USA.

Jenny, H. 1941. *Factors of Soil Formation: A System of Quantitative Pedology*. McGraw Hill Book Co. Inc., New York.

Sehgal, J. 2005. *A Textbook of Pedology: Concepts and Applications*. Second Edition. Kalyani Publishers, New Delhi.

Soil Survey Staff 2000. *Soil Survey Manual*. United States Department of Agriculture. **Handbook No.18**. Scientific Publishers, Jodhpur.

Soil Survey Staff. 2006. *Keys to Soil Taxonomy.* 10th Edition. United States Department of Agriculture. Natural Resources Conservation Service.

Wielding, L.P., Smeck, N.E. and Hall, G.F. 1991. *Pedogenesis and Soil Taxonomy: I. Concepts and Interactions* (**11A**). Elsevier Science Publishing Company Inc., New York.

SSAC 506 SOIL BIOLOGY AND BIOCHEMISTRY (4L+1P) II

Objective

To teach the students the basics of Soil Biology and Biochemistry including nutrient transformation and cycling at the soil-root interface, bioremediation of the contaminated and polluted soils and also the microbial interactions in the soil

Theory

UNIT I

Soil as biological habitat; soil organisms (flora and fauna) – their ecology and diversity; unculturable soil biota.

UNIT II

Rhizosphere biology: Relationships between plant roots and rhizosphere flora.

UNIT III

Energy relationships in organic matter decomposition, energy flow in the plant-microorganisms system; soil enzymes involved in organic matter break down and plant nutrient transformations; microbiology and biochemistry of decomposition of carbonaceous materials: cellulose, hemi-cellulose, lignin and minor plant constituents.

UNIT IV

Microbiology and biochemistry of decomposition of proteinaceous materials; N-cycle, C:N ratio and its importance; theories of humus formation and microbial processes involved; role of humus in soil.

UNIT V

Symbiotic N fixation: The symbionts, biochemical mechanisms of N fixation, factors affecting, importance in sustainable agriculture; microbiology and biochemistry of non-symbiotic N fixation; nitrification, de-nitrification - organisms involved, mechanisms and importance in agriculture; biology of transformation of phosphate solubilization; sulphur, zinc, iron and manganese transformations in soil.

UNIT VI

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.

List of Practicals

Isolation and enumeration of soil microorganisms by serial dilution plate technique; estimation of microbial biomass carbon in soil; study of organic matter decomposition in soil as affected by

varying C:N ratio of crop residues (CO_2 evolution method); determination of dehydrogenase activity in soil; study of acid and alkaline phosphomonoesterases in rhizosphere soil samples; determination of arylsulphatase activity in soils; enumeration of nitrifiers by most probable number method; study of potential nitrogen mineralization in soil; determination of free-living N_2 fixation in soil; determination of soil microbial population; soil microbial biomass; soil enzymes.

Selected Readings

Alexander, M. 1977. *Introduction to Soil Microbiology*. John Wiley and Sons, New York.

Burges, A. and Raw, F. 1967. *Soil Biology*. Academic Press, New York.

Chhonkar, P.K., Bhadraray, S., Patra, A.K. and Purakayastha, T.J. 2007. *Experiments in Soil Biology and Biochemistry*, Westville Publishing House, New Delhi.

Coyne Mark. 1999. *Soil Microbiology: An Exploratory Approach*. Delmer Publishers, USA.

Elsas, J.D.V., Jansson, J.K. and Trevors, J.T., 2007. *Modern Soil Microbiology,* Second Edition. CRC Press, Boca Raton.

Lijbert, B. and Ronald, F.C. 1997. *Soil Ecology in Sustainable Agricultural System*, Lewis Publishers, Boca Raton.

McLaren, A.D. and Peterson, G.H. 1967. *Soil Biochemistry*. **Vol. XI**. Marcel Dekker, New York.

Metting, F.B. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker, New York.

Paul, E.A. and Ladd, J.N. 1981. *Soil Biochemistry*. Marcel Dekker, New York.

Reddy, M.V. (Editor) 1996. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH, New Delhi

Russel, R.S. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill, New York.

Stotzky, G. and Bollag, J.M. 1993. *Soil Biochemistry.* **Vol. VIII**. Marcel Dekker, New York.

Subba Rao, N.S. 1999. *Soil Microbiology*. Oxford & IBH, New Delhi.

Sylvia *et al.* 2005. *Principles and Applications of Soil Microbiology*. Pearson Education (Singapore), New Delhi.

Wood, M. 1989. *Soil Biology*. Chapman and Hall, New York, USA

SSAC 507 SOIL TESTING, WATER QUALITY AND FERTILIZER RECOMMENDATIONS (3L+2P) III

Objectives

To teach the students the basic elements of soil, water and plant testing for accelerated sustainable crop production and environmental production

Theory

UNIT I

Soil testing – its scope and significance in sustainable agriculture; historical background and development of soil testing in India and future challenges; SWOT analysis of soil testing service; soil, plant and water sampling and processing techniques.

UNIT II

Soil test methods – principles and development; soil testing for primary, secondary and micronutrients; diagnosis and amelioration of problem soils; interpretation of soil test data; soil test summaries and soil fertility maps.

UNIT III

Sources of soluble salts and other impurities in water; quality of different water resources in India; interaction of ionic constituents in water with soil; leaching and salt movement through soil; water quality evaluation; factors affecting use of poor quality irrigation water for crop production; management practices for using saline-sodic waters; sewage and industrial effluents for irrigation.

UNIT IV

Different approaches of fertilizer recommendation; critical nutrient concept; targeted yield and multiple regression techniques in soil test crop response studies; formulation of fertilizer dose for different types of crops and cropping systems including cereals, vegetables, ornamental and horticultural crops on normal and problem soils; fertilizer recommendations for rain-fed conditions, integrated plant nutrient supply systems.

UNIT V

Emerging concepts of fertilizer application; synchronizing nutrient supply with plant demand; site-specific nutrient management.

Practicals

Collection of soil and plant samples from agricultural and horticultural crops; sample processing; handling of laboratory instruments; determination of pH, EC and organic carbon; available nutrients (N, P, K, S, B, Zn, Cu, Fe and Mn); estimation of non-exchangeable K; lime requirement of acid soils and gypsum requirement of sodic soils; assessment of irrigation water quality; use of leaf colour chart in real-time N management; calculation of fertilizer doses.

Suggested Readings

Dhyan Singh, Chhonkar, P.K. and Dwivedi, B.S. 2005. *Manual on Soil, Plant and Water Analysis*, Westville Publishing House, New Delhi

Tandon, H.L.S. (Ed.) 1998. *Methods of Analysis of Soils, Plants, Waters and Fertilisers***.** FDCO, New Delhi

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. 1999. *Soil Fertility and Fertilizers: An Introduction to Nutrient Management.* 7th Edition. Pearson Education Pvt. Ltd, New Delhi.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India, New Delhi.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Page, A.L. *et al.* (Ed.) 1982. *Methods of Soil Analysis.* **Part II**. Soil Sci. Soc. Am. Inc., Madison, WI, USA.

Piper, C.S. 1966. *Soil and Plant Analysis*. University of Adelaide, Australia.

Ayers, A.S. and Westcot, D.W. 1976. *Water Quality for Agriculture, Irrigation and Drainage.* **Paper 29**, FAO, Rome.

Richards, L.A. (Editor) 1954. *Diagnosis and Improvement of Saline–Alkali Soils,* **Hand Book 60**, USDA.

SSAC 508 MANURES, FERTILIZERS AND BIOFERTILIZERS (3L+2P) II

Objective

To provide a holistic knowledge to the students on the potential and sustainable use of renewable and non-renewable organic, biological and chemical sources of nutrients; chemistry, technology and usage of chemical fertilizers; and recent developments in the field including customized and fortified fertilizers and relevance of the Fertilizer Control Order.

Theory

UNIT I

Role of manures, fertilizers and biofertilizers in sustainable agriculture; fertilizer production, consumption and agricultural production in India and future projections.

UNIT II

Bulky organic manures, farmyard manure, rural and urban composts: their preparation, preservation and mechanisms of decomposition with variable C/N ratio materials; green manures; enriched and concentrated manures - their preparation, preservation and usages.

UNIT III

Bio-fertilizers - definition, classification and their nutrient potential, mechanisms, production, usage and constraints; strategies for popularizing biofertilizers in India.

UNIT 1V

Agricultural and industrial wastes and effluents as a source of the plant nutrients, problems and constraints; impact on use of sewage and sludge on soil physical, chemical and biological properties.

UNIT V

Manufacture, chemistry, characteristics and use of different nitrogenous, phosphatic and potassic fertilizers; physical and chemical properties of different fertilizers influencing their storage, transport, handling and utilization by crops.

UNIT VI

NP/ NPK complex and customized fertilizers; solid and liquid fertilizers suitable for fertigation, their merits and demerits; recent developments in secondary and micronutrient fertilizers and their usage.

UNIT VII

Approaches for increasing fertilizer use efficiencies - site-specific nutrient management; use of low-grade rock phosphates on different types of soils; long-term effects of manures and fertilizers on soil fertility and productivity.

UNIT VIII

Quality control of fertilizers and Fertiliser (Control) Order Act.

Practicals

Determination of moisture in manures and fertilizers, and determination of biuret in urea; mineralization rates of manures; total, ammoniacal and nitrate nitrogen in manures and fertilizers; total potassium and phosphorus in manures and fertilizers; micronutrients in some micronutrient fertilizers; water soluble, citrate soluble and citrate insoluble P in fertilizers; chloride other than NH_4Cl in ammonium chloride fertilizer; urea-N by hydrolytic method; Ca and S in SSP.

Suggested Readings

Biswas, D.R. 2009. *Practical Manual on Methods of Chemical Analysis of Manures and Fertilizers*. Indian Agricultural Research Institute, New Delhi.

Brady, N.C. and Weil, R.R. 2002. *The Nature and Properties of Soils.* Thirteenth Edition. Pearson Education (Singapore), New Delhi.

Fertilizer (Control) Order, 1985 and the Essential Commodities Act. FAI New Delhi.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Olson, R.A., Army, T.S., Hanway, J.J. and Kilmer, V.J. 1971. *Fertilizer Technology and Use.* Second Edition. Soil Sci. Soc. Am., Madison, Wisconsin, USA.

Prasad, R. and Power, J.F. 1995. *Soil Fertility Management for Sustainable Agriculture*. CRC Lewis, Boca Raton.

SSAC 509 RADIO TRACER TECHNIQUES IN SOIL AND PLANT STUDIES (3L+1P) I

Objective

To train the students in the use of radiotracer techniques in soil-plant studies including assessment of soil fertility, nutrient movement in soil and their absorption by plants

Theory

UNIT I

Radioactivity - discovery, nature and properties of radiations; atomic structure and units of radioactivity; radioisotopes - properties and decay principles; artificial radioactivity, nature and properties of nuclear reactions.

UNIT II

Interaction of radiations with matter; radiation hazards, dosimetry, safety procedures and waste disposal; statistics of counting.

UNIT III

Principles of tracer methodology; principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters, neutron moisture meter, mass spectrometry and radioassay.

UNIT IV

Use of stable isotopes; application of isotopes in ion transport, nutrient transformations; labeling, synthesis of labeled compounds; radio-activation and radiometric analysis.

Practicals

Storage and handling of radioactive materials; familiarization with counting equipments; determination of instrument efficiency of GM counter; determination of half life and decay constant, backscattering, self-absorption and E-max of beta radiations; preparation of soil and plant samples for radioactive measurements, and radioactively-labeled fertilizers; setting up of experiments on fertilizer use efficiency using radioisotopes; determination of A, E and L values of soil using ^{32}P/ ^{65}Zn; use of neutron probe for moisture estimation; measurement of ^{14}C and ^{3}H by

liquid scintillation counting; single channel analyzer for determination of ^{65}Zn; autoradiographic techniques; identification of radionuclides; statistics of radioactive measurements; de-contamination of surfaces.

Suggested Readings

Chase, G. D. and Rabinowitz, J. L. 1964. *Principles of Radioisotope Methodology*. Burgess Publishing Company, Minneapolis 15, Minnesota.

Comer, C.L. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill, New Delhi.

Glasstone S. 1967. *Source Book on Atomic Energy*. East West Press, New Delhi.

IAEA 2001. *Use of Isotope and Radiation Methods in Soil and Water Management and Crop Nutrition*. IAEA, Vienna, IAEA-TCS-14, pp. 247.

IAEA. 1976. *Tracer Manual on Crops and Soils*. **Technical Reports Series No. 171**, IAEA, Vienna.

L'Annunziata, M. F. 1979. *Radiotracers in Agricultural Chemistry*, IAEA, Vienna.

L'Annunziata, M. F. 2003. *Handbook of Radioactivity Analysis*. Academic Press, New York.

L'Annunziata, M. F. 2007. *Radioactivity: Introduction and History*. Elsevier, Amsterdam.

Overman, R.T. and Clark, H.M. 1960. *Radioisotope Techniques.* McGraw Hill Book Company, New York.

Wang, C.H. and Willis, D.L. 1965. *Radiotracer Methodology in Biological Science.* Prentice-Hall, Englewood Cliffs.

SSAC 510/AG 510/ WST 510 MANAGEMENT OF PROBLEM SOILS AND WATERS

(3L+1P) I

Objective

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

Theory

UNIT I

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problem 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

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

UNIT IV

Management of saline and sodic 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 V

Agronomic practices in relation to problem soils; cropping pattern for utilizing poor quality ground waters.

UNIT VI

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters.

UNIT VII

Salt stress: Meaning of salt stress and its effect on crop growth; salt stress injury and resistance in plants; practical ways to overcome the effect of salt stress through soil and crop manipulations.

Practicals

Characterization of acid, acid sulphate, salt-affected and calcareous soils; cations (Na^+, K^+, Ca^{++} and Mg^{++}) in ground water and soil samples; anions (Cl^-, SO_4^{--}, CO_3^{--} and HCO_3^-) in ground waters and soil samples; electrical conductivity and gypsum requirement of salt-affected soils; soil pH and lime requirements of acid soils; salt stress / injury on plants under laboratory conditions; visit to salt-affected / acid soil areas (CSSRI / CPRI).

Suggested Readings

Agarwal, R.R., Yadav, J.S.P. and Gupta, R.N. 1982. *Saline and Alkali Soils of India*. ICAR, New Delhi.

Bear, F.E. 1964. *Chemistry of the Soil*. Oxford and IBH, New Delhi.

Bolt, G.H. and Bruggenwert, M.G.M. 1978. *Soil Chemistry*, Elsevier, Amsterdam, The Netherlands.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson W. L. 2006. *Soil Fertility and Fertilizers*. *An Introduction to Nutrient Management.* Seventh Edition. Prentice Hall, New Delhi.

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

Mahapatra, I.C., Mandal, S.C., Mishra, C., Mitra, G.N. and Panda, N. (Technical Editors). *Acid Soils of India*. ICAR, New Delhi.

USDA Handbook No. 60. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. Oxford and IBH, New Delhi.

SSAC 601 SOIL CLAYS AND CLAY MINERALOGY (3L+1P) II

Objective

To impart the fundamentals of crystallography; structure, classification and identification of soil clays and clay minerals; their agricultural, industrial and environmental uses

Theory

UNIT I

Introduction and elements of crystallography; crystal morphology, constancy of interfacial angles, laws of rational indices, crystallographic axes, Miller indices, symmetry elements, point groups and space groups, crystal classes and systems.

UNIT II

Major geological formations of India; structure and identification of primary minerals; weathering of rocks and minerals, stability index.

UNIT III

Advanced structural features of clay minerals – stacking of 1:1 layers, tetrahedral rotation, thinning of octahedra, M1 and M2 sites, polytypes of mica, hydroxy interlayered minerals; transformation and synthesis of clay minerals and stability diagrams.

UNIT IV

Electrochemical properties of clay; infra-red analysis of clays and clay minerals; electron microscopic and XRD analysis of clay minerals; thermal analysis of clays; chemical and other methods of identification; computation of chemical formula.

UNIT V

Interaction of clay with humus, pesticides, heavy metals; characterization of clay-organic complexes; clay-water interaction.

UNIT VI

Non-crystalline clays in soil and their classification – old and modern; crystallinity of clays, paracrystalline and crystalline with defect; amorphous aluminosilicates, allophane, imogolite – synthesis and properties.

UNIT VI

Clay mineralogical composition of the Indian soils; role of clay minerals in plant nutrition.

Practicals

Separation of sand, silt and clay fraction from soil; identification and quantification of minerals in sand, silt and clay fraction; studies on acid clays; determination of specific surface area and CEC of clay; and estimation of smectite and vermiculite by CEC determination method.

Suggested Readings

Bear, F.E. (Editor) 1964. *Chemistry of the Soil*. Oxford & IBH, New Delhi.

Dixon, J.B. and Weed, S.B. (Editors) 1989. *Minerals in Soil Environments.* Second Edition. Soil Science Society of America, Madison, Wisconsin, USA.

Greenland, D.J. and Hayes, M.H.B. 1981. *Chemistry of Soil Processes*. Wiley, Chichester, USA.

Grim, R.E. 1953. *Clay Mineralogy*. McGraw Hill Publishing Company, New York.

Marshall, C.E. 1965. *Physical Chemistry and Mineralogy of Soils.* **Part I.** *Soil Materials*. John Wiley & Sons, New York.

Mukherjee, S.K. and Biswas, T.D. (Editors) 1976. *Mineralogy of Soil Clays and Clay Minerals*. Indian Society of Soil Science, New Delhi.

Wade, F.A. and Mattox, R.B. 1960. *Elements of Crystallography and Mineralogy*. Oxford and IBH, New Delhi.

SSAC 602 SOIL CHEMICAL ENVIRONMENT AND PLANT GROWTH (3L+2P) II

Objective

To impart the students knowledge on the latest developments on soil chemical environment, soil – solid solution equilbria, soil solution, nutrient movement to plant roots and their absorption by plants and modeling soil-plant processes

Theory

UNIT I

Soil chemical environment – definition and characterization; soil chemical environment - influence of metal toxicity, industrial effluents, sewage, pesticides and fertilizers; radioactive contamination of soil environment; soil factors in relation to greenhouse gases.

UNIT II

Methods of handling solid-solution equilibria in soils; pe+pH – concept and its use for handling the redox systems; solid-solution equilibria of nutrients and pollutant elements – identification of solid phases and influence of pH, redox potential and other soil factors on equilibria operating in the soils.

UNIT III

Concepts of nutrient bioavailability; soil solution – characterization and techniques of extraction, GEOCHEM and related models in chemical speciation; soil solution and plant growth.

UNIT IV

Nutrient ion movement – mechanisms and their relative importance, factors affecting; theory of diffusion and mass flow in root zone.

UNIT V

Root CEC – its role in ion uptake; root ion uptake properties – root morphology, root absorbing power, root demand coefficient; ion uptake theories - mechanisms and kinetics, active and passive absorption.

UNIT VI

Quantitative models on ion uptake – theoretical developments, boundary conditions, validation and sensitivity analysis.

Practicals

Adsorption equilibria of phosphorus and sulphur in soil; cation exchange capacity of plant roots; apparent free space of plant roots; diffusion coefficients and buffer power of nutrients in soil; L and E values in soil; Michaelis-Menten parameters of ion absorption by plants; and prediction of the nutrient uptake by Barber-Cushman Model.

Suggested Readings

Barber, S.A. 1995. *Soil Nutrient Bioavailability. A Mechanistic Approach.* Second Edition. John Wiley & Sons, New York.

Bolt, G.H. and Bruggenwert, M.G.M. 1976. *Soil Chemistry - A Basic Elements.* Elsevier, Amsterdam.

Fried, M. and Broeshart, H. 1967. *Soil-Plant System in Relation to Inorganic Nutrition.* Academic Press, New York.

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Lindsay, W.L. 1979. *Chemical Equilibria in Soils*. Academic Press, New York.

Marschner, H. 1995. *Mineral Nutrition of Higher Plants*. *Second Edition*. Academic Press, London.

McBride, M.B. 1994. *Environmental Chemistry of Soils.* Oxford University Press, New York.

Mengel, K. and Kirkby, E.A. 2001. *Principles of Plant Nutrition.* Fifth Edition. Dordrecht, Kluwer Academic Publishers, The Netherlands.

Mortvedt, J.J., Shuman, L.M. Cox, F.R. and Welch, R.M. (Editors) 1991. *Micronutrients in Agriculture.* Second Edition. Soil Science Society of America, Madison, Wisconsin, USA.

Nye, P.H. and Tinker, P.B. 1977. *Solute Movement in the Soil-Root System*. Blackwell, Oxford, UK.

Wild, A. (Editor) 1988. *Russell's Soil Conditions and Plant Growth*. Longman, Essex, UK.

Wolt, J. 1994. *Soil Solution Chemistry: Applications to Environmental Science and Agriculture.* Wiley, New York.

SSAC 603 NUTRIENTS IN SOILS AND PLANTS (3L+0P) I

Objective

To teach latest developments in soil-plant interactions/ relationships with respect to nutrient management

Theory

UNIT I

Essential nutrients – historical perspective; nutrient status of the world and Indian soils; nutrient content in relation to stages of crop growth and their uptake by crops and cropping systems.

UNIT II

Carbon - a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes; greenhouse effect and climate change; carbon sequestration *vis-à-vis* sustenance of soil quality and crop productivity.

UNIT III

Recent advances in bioavailability, transformation and dynamics of major- and micro-nutrients in soils.

UNIT IV

Growth and the factors affecting it; current approaches in soil fertility evaluation: critical nutrient concentration - concept and determination (graphical and statistical procedures); diagnosis and recommendation integrated system (DRIS).

UNIT V

Nutrient interactions – concepts, chemical and biochemical basis, and models for study; nutrient interactions in soil-plant continuum for maximization of the productivity of crops and cropping systems; water – nutrient interactions under excess and scarce water supply situations; fertigation – an example of water-nutrient synergy.

UNIT VI

Nutrient management in water-logged soils and under organic farming and precision farming.

UNIT VII

Nutrients and crop quality; micronutrients and human health - essential micronutrients list and their critical levels for human health; biofortification – concept, approaches and implications.

Suggested Readings

Goswami, N.N., Rattan, R.K., Dev, G., Narayanasamy, G., Das, D.K., Sanyal, S.K., Pal, D.K. and Rao, D.L.N. 2009. *Fundamentals of Soil Science*. Second Edition. Indian Society of Soil Science, New Delhi.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. and Nelson W. L. 2006. *Soil Fertility and Fertilizers. An Introduction to Nutrient Management.* 7th Edition. Prentice Hall, New Delhi.

Khasawneh, F.E., Sample, E.C. and Kamprath, E.J. (Editors) 1980. *The Role of Phosphorus in Agriculture*. Soil Science Society of America, Madison, Wisconsin, USA.

Mortvedt, J.J., Cox, F.R., Shuman, L.M. and Welch, R.M. (Editors) 1991. *Micronutrients in Agriculture,* Second Edition. Soil Science Society of America, Madison, Wisconsin, USA.

Pierzynski, G.W., Sims, J.T. and Vance, G.F. 2002. *Soils and Environmental Quality,* Second Edition. CRC Press, Boca Raton.

Srivastava, P.C. and Gupta, U.C. 1996. *Trace Elements in Crop Production*. Oxford and IBH, New Delhi.

Stevenson, F.J. (Editor) 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison, Wisconsin, USA.

Sumner, A.M.E. (Editor) 2000. *Handbook of Soil Science*. CRC Press, Boca Raton, USA.

Tandon, H.L.S. (Editor) 1995. *Management of Nutrient Interactions in Agriculture*. FDCO, New Delhi.

SSAC 604/ ES 604 SOIL ORGANIC MATTER (3L+0P) II

Objective

To teach basic biochemistry of soil organic matter, its composition, fractionation and reactions in soil and its significance in sustenance of soil fertility and environmental quality

Theory

UNIT I

Carbon cycle in nature; carbon stocks of the world and Indian soils; pools, composition, and distribution of organic matter in soil.

UNIT II

Biochemistry of the humus formation - theories and pathways for humus synthesis in soil; biochemistry of transformation of N, P and S; organo-metallic interactions and role of chelation in bioavailability of nutrients and pollutant elements.

UNIT III

Characterization of humic substances: Extraction, fractionation and purification; elemental analysis, reactive functional groups of humic substances, ion exchange properties, other colloidal properties; adsorption of organic compounds by clays and role of organic substances in pedogenesis and soil aggregation.

UNIT IV

Soil organic matter (SOM) management in tropics; role of crop residues, tillage, land use and crops and cropping systems in SOM management; carbon sequestration - concept, practices and potential of the world and Indian crop lands; soil carbon stocks – issues and priorities for mitigation and sequestration of organic and inorganic carbon in soils.

UNIT V

Environmental issues related to SOM - greenhouse effect and global warming related to emissions of CO_2, CH_4 and N_2O; organic matter turnover and stabilization in soil - concepts and implications for soil fertility, environmental loads and climate change; soil organic matter dynamics in relation to soil biodiversity in terms of both flora and fauna; carbon transfer model; clean development mechanism – carbon trading; changes in organic carbon turnover in soils - simulation models - Rothamsted Carbon, Century Carbon, Infocrop and DNDC models.

Suggested Readings

Beck, A.J., Jones, K.C., Hayes, M.H.B. and Mingelgrin, U. 1993. Organic *Substances in Soil and Water: Natural Constituents and their Influences on Contaminant Behaviour*. Royal Society of Chemistry, London.

Gieseking, John E. 1975. *Soil Components*. **Vol. 1.** Organic Components. Springer-Verlag, Berlin.

Magdoff, Fred and Weil, R.R. 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press, Boca Raton.

Mercky, R. and Mulongoy, K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture.* John Wiley & Sons, New York.

Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press, New York.

Pierzynski, G.W., Sims, J.T. and Vance, G.F. 2002. *Soils and Environmental Quality,* Second Edition. CRC Press, Boca Raton.

Rees, R.M., Ball, B.C., Campbell, C.D. and Watson, C.A. (Editors) 2001. *Sustainable Management of Soil Organic Matter*. CABI Publishing, Oxon, UK.

Stevenson, F.J. 1994. *Humus Chemistry – Genesis, Composition and Reactions*. Second Edition. John Wiley & Sons, New York.

SSAC 605 SOIL RESOURCE MANAGEMENT (3L+0P) I

Objective

To impart the students basic holistic knowledge on soil resource and latest developments in its sustainable use.

Theory

UNIT I

Relevance of soil management to sustainable agriculture; soil as a natural resource for biomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases.

UNIT II

Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilience and resistance.

UNIT III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation;

history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion - on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semi arid, coastal and *diara* lands.

UNIT IV

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands; land restoration and conservation techniques - erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.

UNIT V

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds.

UNIT VI

Agro-ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

Suggested Readings

Abrol, I.P. and Dhruvanarayana,V.V. 1990. *Technology for Wasteland Development*. ICAR, New Delhi.

Burrough, A. and McDonnell, R.K. 1998. *Principles of Geographical Information System*. Oxford University Press.

Mulders, M.A. 1987. *Remote Sensing in Soil Science*. Elsevier Science Publishers, Amsterdam.

Dent, D. and Young, A.1981. *Soil Survey and Land Evaluation*. George Allen and Unwin, London.

FESL 1993. *An International Framework for Evaluating Sustainable Land Management*, **FAO World Soil Resources Report No. 73, (1993)**, Land Development Division, FAO, Rome.

Lal, R., Blum, W.E.H., Valentine, C. and Stewart, B.A. (Editors) 1988. *Methods for Assessment of Soil Degradation*. CRC Press, Boca Raton.

FAO 1996. Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development. *FAO Land and Water Bulletin*.**5**. FAO, Rome.

ISSS 1994. *Management of Land and Water Resources for Sustainable Agriculture and Environment.* Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi.

Sehgal, J. 1996. *Pedology: Concepts and Application.* Kalyani publishers, New Delhi.

SSSA 1996. *Methods for Assessing Soil Quality*. **SSSA Publication Number 49**, Madison, Wisconsin, USA.

SSAC 606 /ES 606 SOIL AND WATER POLLUTION (2L+1P) II

Objective

To teach the students on extent, causes and mitigation of soil and water pollution on global scale and in India.

Theory

UNIT I

Soil and water resources of India; introduction to soil and water pollution; major soil and water problems; status of pollution in India.

UNIT II

Sources, cause and type of soil pollution; major soil problems – soil erosion, salinity, sodicity, pesticide pollution, and metal pollution.

UNIT III

Physical, chemical and biological characteristics of water; sources and cause of water pollution, point source and non point source pollution, types of pollution in subsurface and surface water, land fill sites and ground water pollution; nitrate, arsenic and fluoride pollution and their control.

UNIT IV

Microbial pollution in water - their sources; common water-borne diseases; transmission and control of water-borne diseases.

UNIT V

Impact of modern trends of agriculture on pollution; effect of soil and water pollution on agriculture and health; characteristics of domestic, municipal and industrial effluents; merits and demerits of their utilization in agriculture.

UNIT VI

Laws and legislation for soil and water pollution, permissible limits of pollutants in soil and water.

UNIT VII

Physical, chemical and biological remediation of soil and water pollution, waste water treatment, integrated nutrient management.

Practicals

Introduction to limnological studies; determination of nitrate and phosphate in soil and waters; determination of EC, pH and alkalinity; free CO_2; dissolved oxygen and residual chlorine in water; fluoride, calcium, magnesium in and hardness of water; trace metallic elements in soil and water; measurement of *Coliform/* MPN; and BOD measurement in natural and waste waters.

Suggested Readings

Ciaccio, Leonard L. 1971. *Water and Water Pollution Handbook*. **Volume 1 to 4**. Marcel Dekker, New York.

Hammer, Mark J. and Hammer, Mark J. (Jr) 1998. *Water and Wastewater Technology.* Third Edition. Prentice Hall of India, New Delhi.

Novotny, V. and Chesters, G. (1981) *Handbook of Non-point Pollution (Sources and Management).* Van Nostrand Reinhold Co., New York.

Pepper, Ian L., Gerba, Charles P. and Brusseau, Mark L. 2006. *Environmental and Pollution Scienc*e. Second Edition. Academic Press, New York.

SSAC 607 MODELLING SOIL PLANT SYSTEM (3L+1P) III

Objective

To train the students in concepts, methodology, technology and use of systems simulation in soil and crop studies

Theory

UNIT I

Introduction, terms and definitions; classification of models; steps of modelling; Taylor series; numerical methods of differentiation and integration; convergence and stability of models.

UNIT II

High level computer language - FORTRAN its commands and usage; testing and evaluation of model.

UNIT III

Description of spatially homogeneous models; K transformation model; model on carbon, nitrogen and phosphorus dynamics in soil.

UNIT IV

Spatially heterogeneous models; equation of continuity; simulation of water flow through soil; explicit and explicit-implicit method; simulation of solute movement through soil by explicit method and with variable moisture flux by explicit-implicit method.

UNIT V

Nutrient uptake models; water uptake models; sensitivity analysis, parameter ranking and model simplification.

Practicals

Testing and usage of FORTRAN commands; writing, compiling, linking and execution of FORTRAN modules on i) K transformation and equilibria in soils, ii) C, N and P transformation in soils, iii) water and salt movement in soils, and iv) nutrient uptake by plants.

Suggested Readings

Benbi, D.K. and Nieder, R. (Eds). 2003. *Handbook of Processes and Modelling in the Soil - Plant System*. Haworth Press.

Datta, S.C. 2007. *Theory and Principles of Simulation Model in Soil and Plant System.* Capital Publishing Company, New Delhi.

Frame, J. and Thornley, J.H.M 1984. *Mathematical Models in Agriculture - A Quantitative Approach to Problems in Agriculture and Related Science*. Butterworth and Co. Ltd.

Frissel, M.I. and Reinger, P. 1974. *Simulation of Accumulation and Leaching in Soils.* Oxford and IBH, New Delhi.

Hanks, J. and Richie, J.T. (Editors) 1991. *Modeling Plant and Soil System*. *Agronomy Bulletin* **31**, ASA, SSSA Madison, Wisconsin, USA.

Nielsen, D.R. and MacDonald, J.G. (Editors) 1984. *Nitrogen in the Environment. Nitrogen Behavior in Field Soils*. Academic Press, New York.

Shaffer, M.J., Ma, L. and Hansen, S. (Editors) 2001. *Modeling Carbon and Nitrogen Dynamics for Soil Management*. Lewis Publishers, Boca Raton.

Tsuji, G.Y., Gerrit, H. and Philip, T. 1998. *Understanding Options for Agricultural Production.* Kluwer, Amsterdam. .

Web sites

Documentation of the respective models. (http://www.simulistics.com/ for Simile; http://www.iseesystems.com for Stella; and http://www.vensim.com/software.html for vensim PLE)

http://www.icasa.net/dssat/index.html for DSSAT; http://www.brc.tamus.edu/epic/ for EPIC

http://www.nrel.colostate.edu/projects/century/ for Century

http://www.alterra.wur.nl/NL/for WOFOST

http://www.apsru.gov.au/ apsru/Default.htm for APSIM

http://eco.wiz.uni-kassel.de/ecobas.html online Register of ecological models

Plentinger, M.C. and Penning de Vries, F.W.T. (Editors) 1996. CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO)

Agricultural Systems – Elsevier at http://www.elsevier.com/wps/product/cws_home /405851

SSAC 611/ AP 611 SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH (3L+1P) III

Objective

To impart knowledge on 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

Nutrients: 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 and 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, and development of sustainability indices.

List of Practicals

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; germination percentage as affected by temperature; estimation of evapo-transpiration losses under different management options; measurement/estimation of consumptive water use, production functions, field water balance components, and water uptake by plants.

Suggested Readings

Doorenbos, J. and Pruitt,W.O. 1975. *Crop Water Requirements, FAO, Irrigation and Drainage Paper* **24**. FAO Rome.

Hanks, R.J. and Ascheroft, G.L. 1980.*Applied Soil Physics: Soil Water and Temperature Applications.* Springer Verlag, Berlin.

Hillel, D. 1971. *Soil and Water: Physical Principles and Processes*. Academic Press. New York.

Hillel, D. 1998. *Environmental Soil Physics*. Academic Press, New York

Slatyer, R.O. 1967. *Plant- Water Relations*. Academic Press, New York.