NEW AND RESTRUCTURED POST-GRADUATE CURRICULA & SYLLABI

Physical Sciences

Agricultural Meteorology
Agricultural Physics
Agronomy
Soil Science

Education Division
Indian Council of Agricultural Research
New Delhi

April 2009

Contents

EXECUTIVE SUMMARY

Agricultural Meteorology

- 17 courses, 9 of 500 series and 8 of 600 series, in addition to one credit seminar at Master's level and two at Doctoral level recommended
- 4 courses of 500 series recommended as core courses for master's degree
- Course contents revised and new courses added on risk management due to climate change, climate change and livestock management, crop-weather modeling, air pollution, use of GIS tools in climate studies, and instrumentation and analytical tools
- Practical courses added in 600 series courses for more hands-on training of students

Agricultural Physics

- 18 courses, 11 of 500 series and 7 of 600 series, in addition to one credit seminar at Master's level and two at Doctoral level recommended
- 4 courses of 500 series recommended as core courses for master's degree
- The course curriculum includes courses on soil physics, climatology and biophysics
- Course contents revised to update the existing courses and new courses on the use of remote sensing and GIS in studies related to Agricultural Physics included in course curriculum to accommodate the aspirations of private and public sector
- Practical added in 600 series for better hands-on traing of students

Agronomy

- 22 courses, 13 of 500 series and 9 of 600 series, in addition to one credit seminar at Master's level and two at Doctoral level recommended
- 4 courses of 500 series recommended as core courses for master's degree
- The course curriculum includes courses on crop production- cereals, pulses, oil seeds, fodder, weed control, climatology, fertilizer management and irrigation management
- New courses on current trends in Agronomy, organic farming, integrated farming systems, stress crop production, watershed management and crop modeling have been recommended
- Practical added in 600 series

Soil Science

- 21 courses, 15 of 500 series and 6 of 600 series, in addition to one credit seminar at Master's level and two at Doctoral level recommended
- 5 courses of 500 series recommended as core courses for master's degree
- The contents of regular courses on pedology, soil fertility and chemistry, soil physics, soil erosion and conservation, soil biology, use of radioisotopes in soil

research and instrumentation revised in the light of recent demands of industry and society

- New courses on air, soil and water pollution, use of remote sensing and GIS techniques in soil research, land degradation and restoration principles and processes, and watershed management included in the course curriculum
- The present course is designed to educate the students about the basics of soil science, soil processes and their implications in crop production. Contents on various soil degradation processes, their economic and social implications, and their amelioration techniques are the focus of attention. The students shall be exposed to latest technologies in soil studies and prediction models for better managing soils keeping in view the future projections.

BSMA Committee on Physical Sciences

(Ag. Met./Soil Science & Agri. Chem./Water Conservation/Irrigation & Water Mgt./Ag. Phy./Agronomy)

(Constituted by ICAR vide Office order No. F. No. 13 (1)/2007- EQR dated January 14, 2008)

Name	Address	Specialization
Dr. P.K. Sharma Dean PGS **Convener**	CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur 176 062	Agricultural Physics
Dr. A. Sreenivasa Raju Prof. & Univ. Head	Dept. of Soil Science & Agri. Chemistry, College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendra Nagar, Hyderabad-500030	Soil Science
Dr Bijay Singh National Prof.	Department of Soil Science, Punjab Agricultural University, Ludhiana 141 004	Soil Fertility
Dr T. B. S. Rajput Principal Scientist	Water Technology Center, Indian Agricultural Research Institute, New Delhi 110012	Water Resources
Dr A. K. Sarkar Dean	College of Agriculture, Birsa Agricultural University, Kanke, Ranchi, Jharkhand- 834 006	Soil Fertility
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Dr S. K. Sanyal Director Research	Flat no. A-1, Saptaparni, 58/3, Ballygunge Circular Road, Kolkata	Soil Chemistry
Dr A.M. Sheikh Dean	College of Agriculture, Anand Agricultural University, Anand-388110	Agromet
Dr. K.K. Singh Professor	Deptt. of Irrigation & Drainage Engg., College of Technology, GB Pant University of Agriculture & Technology, Distt. Udham Singh Nagar, Pantnagar-263145	Water Management
Dr R. K. Rattan Principal Scientist **Member Secretary**	Division of Soil Science and Agricultural Chemistry, IARI, New Delhi 110 012	Soil Science

Co-opted Member

Dr (Mrs) Usha Kiran Chopra, Professor — Division of Agricultural Physics, IARI, New Delhi-110 012

PREAMBLE

Importance of the Subject to Agriculture/Farming Society/Society in General

Agricultural Meteorology

Agricultural Meteorology is a branch of Meteorology that examines the effects and impacts of weather and climate on crops, rangeland, livestock, and various agricultural operations. Weather information and forecasts are the two important aspects of Meteorology and they are of vital importance to agriculture, fisheries, water management and disaster mitigation etc. Knowledge of Agricultural Meteorology helps in the efficient management of agro-climatic resources and crop microclimate modifications for the sustainability of agricultural production system. The Agro-meteorologist requires not only a sound knowledge of Meteorology, but also of Agronomy, Plant Physiology and Plant and Animal Pathology, in addition to common agricultural practices. This branch of Meteorology is of particular relevance to India because of the high dependence of our agriculture on monsoon rainfall which has its own vagaries. Further, it is very well recognized that climate is not static and issues such as climate change and global warming are receiving increasing attention. Recent advances in satellite and computer technology have led to significant progress in Agricultural Meteorology. The objective of this discipline is to educate students on the understanding of climate and weather elements, principles and processes, and their impact on agricultural activities.

Agricultural Physics

Agricultural Physics deals with the application of physical principles and processes in agriculture. It deals with the aspects of soil, water and environment, three natural resources and key factors in crop production. Understanding of these natural resources is essential to manage them optimally and on sustainable basis. The subject gains special significance at a time when climate change, global warming, environmental- soil, air, water- pollution and declining factor productivity have become major issues of concern in agricultural sector. Since these factors are highly dynamic in nature, their continuous monitoring and understanding becomes all the more essential. In view of the introduction and applications of newer techniques are being increasingly used in the Agricultural Physics, periodic revisions of the courses and curricula have become necessary to keep the faculty and the student community updated about these developments.

Agronomy

Agronomy is not just plowing and planting, but a major component of agro-ecology which includes several activities that affect the environment and human populations. An Agronomist remains in the center of efforts to work with issues related to environmental and ecological concerns, and to increase the production of food, feed, fuels and fiber for a growing world citizenry. Agronomists today are involved with many issues including producing food, creating healthier food, managing environmental impacts, and creating energy from plants. Research activities in Agronomy focus on systems analysis and simulation modeling of environmental and management impacts on agricultural production; these are key to sustainability of the agriculture production systems. In fact, agronomy is a discipline that combines the application of sciences like Biology, Chemistry, Ecology, Earth Science, and Genetics. It is a science that directly deals with the crop production technologies with a view to improve and sustain factor productivity; decline in factor productivity is the major cause of concern to Agricultural Scientists

today. The significance of agronomy in agriculture and to Society can never be undermined.

Soil Science

Study of soils is the key to understand how an ecosystem works. Soil is a store house of water and nutrients to plants, filter for wastes, home to organisms, and is critical for recycling elements vital for plant growth, as well as organic and inorganic wastes. Moreover, soil is a location for buildings- the physical support to life. Soil management is essential in our continued quest to increase the production of food, feed, fiber, and fuel while maintaining and improving the environment, and mitigating the effects of climate change. Being the essence of all terrestrial life and ecosystem services, we cannot take the soils for granted. Soil is the basis of survival for present and future generations. Due to overexploitation of soil resource for different purposes by the society, soil is undergoing several degradation processes, putting the soil quality at a stake, and threatening the sustainability of food productivity globally. It is nearly impossible to feed burgeoning population without maintaining soil health. Soil professionals have an important role to play in optimally managing soil resources. The Soil Scientists and soil professionals continue to enrich the lives of all human beings by improving stewardship of the soil, combating soil degradation, and ensuring the future protection and sustainable use of our air, soil, and water resources. Can we think of good agriculture without good soils? The future of all life is directly linked to our understanding and appreciation of soil and land management.

Present Status of Agricultural Education *vis-a-vis* State of Agriculture

The education status in agriculture *per se* and in four disciplines mentioned above has remained encouraging; the many-fold increase in agricultural productivity over a period of few decades is a proof of it. Without progress in agriculture sector, it would not have been possible to meet the food and related demands of the increasing population. The increasing pressure of multiplying food production has led to the overexploitation and thus degradation of natural resources, decline in factor productivity, environmental pollution, climate change, increasing costs of production and instability in system productivity. This has alerted the agricultural scientists and necessitated review of policy planning in agriculture.

Need for Revision of Course Curricula and Syllabi

Agriculture is a dynamic subject. To meet the challenges of modern Society, agriculture must tune to the changing scenarios. As stated above, agriculture as a sector has done satisfactorily for the society, but needs a fresh look in light of new challenges posed by changes taking place globally in terms of education, knowledge, and needs and preferences of the society, and related impacts on climate and other natural resources. Accordingly, it has necessitated revision of course curricula and syllabi for higher education in agriculture. The teaching and research in Agricultural Meteorology, Agricultural Physics, Agronomy and Soil Science to postgraduate students must include topics of latest concerns like climate change, global warming, degradation of natural resources- soil, water and environment, disaster management, stress cultivation, prediction models in soil health and crop growth, green-house gases, water resources, economy aspects, sustainability issues etc. More emphasis is needed on imparting knowledge on the use of modern computer-aided techniques like GIS, remote sensing, and electronic gadgets

and equipments for precise measurements. Course curricula and syllabi must keep a pace with the changing demands of the society.

Revision Process Adopted by BSMAC

The Indian Council of Agricultural Research (ICAR, referred to as 'Council' also) constituted a National Core Group (NCG) consisting of 12 eminent academicians, renowned agricultural scientists and distinguished extension specialists. The NCG is led by Dr. J. C. Katyal, Vice Chancellor, CCS Haryana Agricultural University, Hisar. The NCG has been mandated to: i) Redefine names of Courses and accordingly re-script Curricula of Masters' and Ph. D. programmes for uniformity and modernity, and ii) Revise corresponding syllabi for further strengthening from the point of employability, responsiveness to existing and emerging concerns of farmers and farming and country's development goals and international commitments and obligations. In pursuance of this mandate, NCG divided existing 60 Post-graduate (PG) courses into 18 broad subject matter area groups. Interconnectivity of diverse courses, closeness of syllabi, convenience of available faculty and proximity of common teaching and learning facilities were the major considerations of broad subject matter groupings.

On the recommendations of the NCG, the ICAR constituted 18 Broad Subject Matter Area Committees (BSMAC). Each BSMAC comprised of about 10 eminent subject-matter specialists/academicians who were authorized to revise and rewrite the PG course curricula for updating, futuristic outlook and built-in possibility for re-strengthening as per need and appropriateness. The Physical Sciences Group covered four disciplines, viz. Agricultural Meteorology, Agricultural Physics, Agronomy and Soil Science. The 11 members constituted the Physical Sciences Group, 10 members suggested by NSG, and one member co-opted in the discipline of Agricultural Physics (ANNEXURE-I).

A meeting of the Conveners and the Member Secretaries of different BSMACs with the Chairman and Members of the NCG was held on February 14, 2008 at New Delhi. The DDG (Edn), ICAR also participated and addressed the participants. During this meeting, a base document on possible course curricula, prepared by a select group of the CCS Haryana Agricultural University Faculty under the guidance of Chairman, NCG and Vice Chancellor, CCS HAU, was presented. This unique effort of CCS HAU provided to each BSMAC a canvas on which redrafted and re-crafted course curricula could be inked for maintaining cross-university consistency and novelty.

During the February Meeting, deliberations were also held on common issues like nomenclature, credit load for M.Sc. and Ph.D. programmes, division of credit hours into major, minor and supporting subjects and research, etc. Discussions specifically focused on future course of action and time schedule to be adhered to by each BSMAC. It was agreed that each BSMAC would organize three to four meetings and interact with other experts in the relevant field before arriving at decisions on strengthening and modernization of the course curricula. Each BSMAC will also systematize nomenclature, credit load, qualifying and continuing over all grade point averages, examination system etc. Before finalizing the report, all BSMACs were also advised to hold a Workshop ensuring participation, besides others, of a good number of stakeholders of the PG courses being developed. It was also agreed that each BSMAC will submit its report to the Member Secretary by May 31, 2008.

The minutes of the meeting were circulated immediately through e-mail to all members for information and necessary action. First meeting of Physical Sciences Group was held at IARI, New Delhi on April 4, 2008. Proceedings of the meeting are enclosed (ANNEXURE II). The members have already prepared revised course contents in respective disciplines. These contents were distributed to all the members as well as thoroughly discussed in the meeting. Four groups were then identified, one group in each discipline, to further examine and revise the course-content drafts by consulting course contents being currently followed in other institutions. Simultaneously, several stakeholders were also contacted on phone and through e-mail for their input in the course contents (ANNEXURE III). The suggestions made by these stakeholders were also incorporated into revised syllabi. Through a series of interactions on phone and e-mail among members and with the stakeholders, Physical Sciences Group finalized the first draft of recommendations and submitted to the Coordinator.

In order to discuss the draft of recommendations and report, a combined meeting of the NCG and Conveners and Member Secretaries of each BSMAC was held in the Lecture Hall, NASC Complex, New Delhi on 23-24 June, 2008. At least one additional member from each BSMAC to facilitate discussion on a specific subject and a chosen group of specialists was also invited for their input and advice. Dr. S.P. Tiwari, DDG (Edn), Dr. B.S. Bisht, ADG (HRD) and Dr. G.C. Tiwari, ADG (EPD), ICAR; Dr. A.K. Wahal, DDG (Edn), ICFRI, Dehradun and Dr. A.K. Srivastava, Director, NDRI, Karnal were also present. Individual reports of the 18 BSMACs were presented by Conveners/Member Secretaries over a period of two days. During the discussions, several general issues were also discussed and the recommendations were made about the academic regulations for Master's and Ph.D. programmes. Also, several suggestions, both general as well as specific to a BSMA committee report, were made for improvement of the course content and their presentation to bring in uniformity across different disciplines. The final report is based on these recommendations.

Salient Features of the New Curricula/Syllabi along with Justification

The revised course curricula is designed taking into consideration the needs and aspirations of the society, especially the students and the farming community. Attempt has been made to frame courses in such a way that the students aquire latest knowledge in the field and become professionals with capabilities of entreprenureship. More emphasis is laid on the hands-on training and for that more practical courses have been included even at Ph. D. programme.

Career Opportunities

The graduates are expected to become professionals in their respective fields, capable of

- Starting their own entrepreneurship and creating jobs for others too
- Employment in Private Sector
- Employment in Public Sector

ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's Programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.

AGRICULTURAL METEOROLOGY

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
AGM 501*	FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY	2+1
AGM 502*	FUNDAMENTALS OF AGRICULTURAL METEOROLOGY	2+1
AGM.503*	MICROMETEOROLOGY	2+1
AGM 504*	AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION	1+2
AGM 505	SOIL WATER BALANCE CLIMATOLOGY	2+1
AGM 506	CROP WEATHER MODELS	1+2
AGM 507	WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES	2+0
AGM 508	PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE	2+1
AGM 509	APPLIED AGRICULTURAL CLIMATOLOGY	1+2
AGM 591	MASTER'S SEMINAR	1+0
AGM 599	MASTER'S RESEARCH	20
AGM 601	CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT	2+1
AGM 602	WEATHER FORECASTING	2+1
AGM 603	AIR POLLUTION METEOROLOGY	2+1
AGM 604	WEATHER, CLIMATE AND LIVESTOCK	2+1
AGM 605	ANALYTICAL TOOLS AND METHODS FOR AGRO-METEOROLOGY	2+1
AGM 606	STRATEGIC USE OF CLIMATIC INFORMATION	2+1
AGM 607	MATHEMATICS IN AGRICULTURE AND BIOLOGY	2+1
AGM 608	DATABASE MANAGEMENT AND COMMERCIALIZATION OF AGROMETEOROLOGICAL DATA IN E-SERVICES	1+2
AGM 691	DOCTORAL SEMINAR I	1+0
AGM 692	DOCTORAL SEMINAR II	1+0
AGM 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme

AGM 501 FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY 2+1

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory

UNIT I

Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation of pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.

UNIT II

Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit, stability and instability conditions in the atmosphere.

UNIT III

Lapse rates-ascent of dry and moist air, condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT IV

Effect of earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon.

UNIT V

Crop weather charts, calenders and diagrams; weather forecasting importance, types, tools, and modern techniques of weather forecasting; El Nino, la Nino and ENSO.

UNIT VI

Instruments for measurement of meteorological elements; agromet observatory; measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function; water budgeting; synoptic, numerical, graphical, spatial analysis of weather systems and charts technique.

Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Site selection and installation procedures for meteorological instruments
- Measurement of weather parameters.
- Reading and recording, calculation of daily, weekly, monthly means.
- Totals of weather data.
- Climatic normals, weather chart preparation and identification of low pressure systems and ridges.
- Statistical technique for computation of normals, moving average, marton chain model etc.

Suggested Readings

Barry RG & Richard JC. 2003. *Atmosphere, Weather and Climate*. Tailor & Fransics Group.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Ghadekar SR. 2001. *Meteorology.* Agromet Publ.
Mcllveen R. 1992. *Fundamentals of Weather and Climate*. Chapman & Hall.
Petterson S. 1958. *Introduction to Meteorology*. McGraw Hill.
Trewartha Glenn T. 1954. *An Introduction to Climate*. McGraw Hill.

AGM 502 FUNDAMENTALS OF AGRICULTURAL METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory

UNIT I

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

UNIT II

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

UNIT III

Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

UNIT IV

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

UNIT V

Meteorological aspects of forest fires and their control; concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.

UNIT VI

Climatic change, green house effect, CO_2 increase, global warming and their impact on agriculture; concept and types of drought; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical

- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relation in different crops.
- Preparation of weather based agro-advisories
- Use of automated weather station (AWS)

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book Co.

Varshneya MC & Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

AGM 503 MICROMETEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere.

Theory

UNIT I

Properties of atmosphere near the earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection**.**

UNIT II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; temperature instability, air pollution; microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raymonds analogy, Exchange coefficients.

UNIT III

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

UNIT IV

Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation; remote sensing in relation to micrometeorology.

Practical

- Micrometerological measurements in crop canopies
- Quantification of crop microclimate
- Determination of ET and its computation by different methods

Suggested Readings

Arya S Pal. 1988. *Introduction to Micrometeorology*. Academic Press.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Gates DM. 1968. *Energy Exchange in the Biosphere*. UNESCO.

Goudriaan J. 1983. *Crop Micrometeorology: A Simulation Study*. Scientific Publ.

Grace J. 1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.

Gupta PL & Rao VUM. 2000. *Practical Manual on Micrometeorology*. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
Jones HG. 1992. *Plants and Micriclimate*. Cambridge Univ. Press.
Munn RE. 1970. *Biometeorological Methods*. Academic Press.
Rosenberg NJ. 1974. *Microclimate – The biological Environmet*. John Wiley & Sons.
Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

AGM 504 AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION 1+2

Objective

To impart the theoretical and practical knowledge of instruments/equipments used for measurement of agro-meteorological variables.

Theory

UNIT I

Fundamentals of measurement techniques; theory and working principles of barometers, thermometers, psychrometers, hair hygrometer, thermo-hygrograph; exposure and operation of meteorological instruments/ equipments in agromet observatories.

UNIT II

Radiation and temperature instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder, quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.

UNIT III

Precipitation and dew instruments: working principles of rain gauge, self recording rain gauge, Duvdevani dew gauges.

UNIT III

Wind instruments: working principles of anemometer, wind vane, anemograph.

UNIT IV

Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter.

UNIT V

Soil thermometers, soil heat flux plates, instruments for measuring soil moisture.

UNIT VI

Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical

- Working with the above instruments in the meteorological observatory taking observations of relevant parameters
- Computation interpretation of the data

Suggested Readings

Anonymous. 1987. *Instructions to Observers at Surface Observatories*. Part I, IMD, New Delhi.
Byers HR. 1959.*General Meteorology*. McGraw Hill.

Ghadekar SR. 2002. *Practical Meteorology: Data Acquisition Techniques, Instruments and Methods*. Agromet Publ.

Middleton WE & Spilhaws AF. 1962. *Meteorological Department*. University of Toronto Press.

Tanner CB. 1973. *Basic Instrumentation and Measurements for Plant Environment and Micrometeology*. University of Wisconsin, Madison.

AGM 505 SOIL WATER BALANCE CLIMATOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of ET estimation and measurements.

Theory

UNIT I

Basic Laws of radiation; radiation interaction with plant environment; energy balance in atmosphere, crop canopy.

UNIT II

Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.

UNIT III

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration - modified techniques.

UNIT IV

Influence of microclimatic, plant, soil and cultural factors; techniques of lysimetry in measuring actual evapotranspiration.

UNIT IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, Kc values and their use, dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; computation of K_C values and their use; estimation of evapotranspiration through satellite imageries – MODIS, TERRA, AQUA, AVHRR, NOVA etc.; modeling for potential ET & reference ET, and ET through remote sensing.

Practical

- Measurement and evaluation of radiation components
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Measurement of wind and temperature profiles near the ground

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Burman R & Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.

Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.

Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.

Ram Niwas, Diwan Singh & Rao VUM. 2000. *Pratical Manual on Evapotranspiration*. Dept. of Agril. Meteorology, CCS HAU Hisar.

Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.

AGM 506 CROP WEATHER MODELS 1+2

Objective

To impart the theoretical and practical knowledge of various models for estimation of crop weather responses.

Theory

UNIT I

Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.

UNIT II

Empirical and statistical crop weather models their application with examples; regression models- incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e. g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; forecasting of pests and diseases; verification, calibration and validation of models.

Practical

- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP etc.

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

DeWit CT, Brouwer R & de Vries FWTP. 1970. The Simulation of Photosynthetic Systems. pp. 7-70. In. *Prediction and Measurement of Photosynhetic Activity*. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.

Duncan WG. 1973. SIMAI- A Model Simulating Growth and Yield in Corn. In: *The Application of Systems Methods to Crop Production* (D.N. Baker, Ed.). Mississippi State Univ. Mississipi.

Frere M & Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting*. FAO.

Hanks RJ. 1974. Mode for Predicting Plant Yield as Influenced by Water Use. *Agron. J.* 66: 660-665.

Keulen H Van & Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop.* Simulation Monographs. PUDOC, Wageningen.

AGM 507 WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES 2+0

Objective

To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory

UNIT I

Historical reviews of weather modification, present status of weather modification for agriculture; atmospheric composition and green house effect.

UNIT II

Theories of weather modification; scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

UNIT III

Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture in the continent/region/country/sub-region concerned and the related documented risk concepts; history and trends of defense strategies towards such risks in the same continent region/country/sub-region; preparedness for weather and climate risks.

UNIT IV

Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; modern tools inlcuidng remote sensing and GIS in monitoring and combating droughts.

UNIT VI

Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.

UNIT VII

Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/region/country/sub-region concerned and their documented evidence of application to agricultural/farming systems; strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

UNIT VIII

Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives; challenges for developing coping strategies including transferring risks through insurance schemes.

UNIT IX

Challenges to coping strategies - combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; quantification of risk in agricultural systems associated with weather and

climate; methods for risk assessment and application to agricultural systems of local and regional interest; application of risk management approaches to problems associated with weather and climate problems; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings

Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmoshperic Science and Climate*. National Research Council, USA.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Chritchfield HJ. 1994. *General Climatology*. Prentice Hall.

Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.

Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.

Menon PA. 1989. *Our Weather.* National Book Trust.

Pearce RP. 2002. *Meteorology at the Millennium*. Academic Press.

Rosenberg NJ, Blad BL & Verma SB. 1983. *Microclimate – The Biological Environment.* John Wiley & Sons.

Samra JS, Pratap Narain, Rattan RK & Singh SK. 2006. *Drought Management in India*. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

AGM 508 PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE 2+1

Objective

To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory

UNIT I

Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

UNIT II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

UNIT III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.

UNIT IV

Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction.

UNIT V

Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

UNIT VI

Digital techniques for crop discrimination and identification; crop stress detection - soil moisture assessment, inventory of ground water and satellite

measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation.

UNIT VII

Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations
- Differentiation of different degraded soils
- Time domain reflectometry
- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Colwell RN. (Ed.*). Manual of Remote Sensing*. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.

Curan PJ. *Principles of Remote Sensing*. ELBS/Longman.

Georg Joseph 2005. *Fundamentals of Remote Sensing*. University Press (India).

Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.

Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.

Patel AN & Surender Singh 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

AGM 509 APPLIED AGRICULTURAL CLIMATOLOGY 1+2

Objective

To impart the theoretical and practical knowledge of computation of different bio-parameters and their applications in the agriculture.

Theory

UNIT I

Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.

UNIT II

Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.

UNIT III

Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT IV

Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.

UNIT V

Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agro-meteorological variables using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

Suggested Readings

Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Lal DS. 1989. *Climatology*. Chaitanya Publ. House.

Mather JR. 1977. *Work Book in Applied Climatology*. Univ. of Delware, New Jersey.

Mavi HS & Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.

Raj Singh, Diwan Singh & Rao VUM. 2006. *Manual on Applied Agricultural Climatology*. Dept of Agril Meteorology, CCS HAU Hisar, India.

Subramaniam VP. 1977. *Incidence and Spread of Continental Drought*. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.

Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.

Walter J Saucier 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

AGM 601 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT 2+1

Objective

To impart the theoretical and practical knowledge of climate change and their sources.

Theory

UNIT I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; astronomical predictions: lunar cycle, sunspot cycle, soil-lunar tides, Chandlers compensation, blocking highs.

UNIT II

Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services; climate change and crop diversification, loss of biodiversity, microbes and pest dynamics; climate change and storage, climate change and weed management.

UNIT III

Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

UNIT IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

UNIT V

Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods etc.

Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture
- Advance methodology of assessing the impact of climate change on crops

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ.

Anonymous. *IPCC Assessment Reports on Climate Change (2001, 2007)*. WMO, UNEP Publ.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Jepma CJ & Munasinghe M. 1998. *Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.

Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses.* Cambridge Univ. Press.

Pretty J & Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.

Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.

Salinger J, Sivkumar MVK & Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.

Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

AGM 602 WEATHER FORECASTING 2+1

Objective

To impart theoretical and practical knowledge of forecasting techniques used for weather prediction and preparation of agro-advisories.

Theory

UNIT I

Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.

UNIT II

Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano-technological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior; various methods of verification of location-specific weather forecast.

UNIT III

Weather based advisories: interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination.

UNIT IV

Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

UNIT V

Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behavior of clouds.

Practical

- Exercise on weather forecasting for various applications
- Preparation of weather-based agro-advisories based on weather forecast using various approaches and synoptic charts.

Suggested Readings

Alan Watts 2005. *Instant Weather Forecasting*. Water Craft Books.

Ram Sastry AA. 1984. *Weather and Weather Forecasting*. Publication Division, GOI, New Delhi.

Singh SV, Rathore LS & Trivedi HKN. 1999. *A Guide for Agrometeorological Advisory Services*. Department of Science & Technology, NCMRWF, New Delhi.

Wegman & Depriest 1980. *Statistical Analysis of Weather Modification Experiments*. Amazon Book Co.

AGM 603 AIR POLLUTION METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of air pollutants.

Theory

UNIT I

Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution.

UNIT II

Sources of air pollution; classification and properties of air pollutants; emission sources, importance of anthropogenic sources; behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.

UNIT III

Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; meteorological conditions and typical plume forms; air pollution forecasting – Gaussian diffusion models, Numerical dispersion models.

UNIT IV

Air quality standards; effect of air pollution on biological organisms; ozone layer depletion; air pollution control technologies; management of air pollution; principles of diffusion of particulate matter in the atmosphere; air pollution laws and standards.

UNIT V

Air pollution sampling and measurement: types of pollutant sampling and measurement, ambient air sampling, collection of gaseous air pollutants, collection of particulate pollutants, stock sampling; analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.

UNIT VI

Scales of air pollution: local, urban, regional, continental and global.

Practical

- Measurement of different air pollutants
- Measurement of different air pollution gases
- Measurement of visibility
- Measurement of ozone and aerosol optical thickness (AOT)
- To study the temperature profile at different heights
- To study the stability of the atmosphere
- To determine height of partial flume through chimani
- To study the effect of temperature on vegetables, orchards and agricultural crops

Suggested Readings

Arya SP. 1998. *Air Pollution Meteorology and Dispersion*. Oxford Univ. Press.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
Chhatwa GR. 1989. *Environmental Air Pollution and its Control*. Anmol Publ.
Mishra PC. 1990. *Fundamentals of Air and Water Pollution*. Ashish Publ.
Mudd J Brian & Kozlowski TT. (Ed.). 1975. *Responses of Plants to Air Pollution*. Academic Press.
Pickett EE. 1987. *Atmopheric Pollution*. Hemisphere Publ. Corp.
Sharma SH & Khan TI. 2004. *Ozone Depletion and Environmental Impacts*. Pointer Publ.
Weber E. 1982. *Air Pollution Assessment Methodology and Modeling*. Plenum Press.
Yunus M & Iqbal M. (Eds.). 1996. *Plant Response to Air Pollution*. John Wiley & Sons.

AGM 604 WEATHER, CLIMATE AND LIVESTOCK 2+1

Objective

To impart the theoretical and practical knowledge of weather, climate for livestock management.

Theory

UNIT I

Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.

UNIT II

Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders.

UNIT III

Meteorological conditions prevailing in glass-house, green house, animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors.

UNIT IV

Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

UNIT V

Management of livestock to reduce greenhouse gas emission.

Practical

- Measurement of temperature, humidity, net radiation
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of enegy fluxes on body
- Measurements of CO_2 and methane in animal farm house

Suggested Readings

Kaiser HM & Drennen TE. (Eds). 1993. *Agricultural Dimensions of Global Climate Change*. St. Lucie Press, Florida.
Monteith L & Unsworth M. 2007. *Principles of Environmental Physics*. 2nd Ed. Academic Press.
Takahashi J, Young BA, Soliva CR & Kreuzer M. 2002. *Greenhouse Gases and Animal Agriculture.* Proc. 1st International Conference on Greenhouse Gases and Animal Agriculture.

Tromp SW. 1980. *Biometeorology. The Impact of the Weather and Climate on Humans & their Environment. (Animals & Plants)*. Heyden & Son Ltd.

AGM 605 ANALYTICAL TOOLS AND METHODS FOR AGRO-METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of new tools for analysis of agro-climatic features.

Theory

UNIT I

Review of agro-climatic methods; characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.

UNIT II

Network spacing; spatial and temporal methods; GIS fundamentals and applications; numerical characterization of climatic features; crop response to climate, time lags, time and distance constants, hysteresis effects.

UNIT III

Influence of climate on stress-response relations; thermal time approach in agroclimatology- heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction; comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.

UNIT IV

Instrumentation and sampling problems; design of agro-meteorological experiments.

UNIT V

Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual basic.

UNIT VI

Empirical and statistical crop weather models and their application with examples; incorporating weather, soil, plants and other environment-related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation models; forecasting models for insects and diseases.

Practical

- Calculation of continentality factors.
- Climatic indices and climogram.
- Agrometeorological indices: Degree-days, photothermal units, heliothermal units, phenothermal index.
- Heat and radiation use efficiency and other indices of crops.
- Crop growth rates.
- Analysis of thermogram, hygrogram, hyetogram, sunshine cards etc. stream lines and wind roses and statistical analysis of climatic data.
- Working with statistical models: crop yield forecasting, crop weather relationship and insect & disease forecasting models.
- Working with crop simulation models
- Small programme writing in computer languages like BASIC, FORTRAN, C, C++ and Visual basic.

- Geographical Information System.

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Cooper M. 2006. *The Spirit of C. An Introduction to Modern Programming*. Jaico Publ.

Malczewski J. 1999. *GIS & Multicriteria Decision Analysis*. John Wiley & Sons.

AGM 606 STRATEGIC USE OF CLIMATIC INFORMATION 2+1

Objective

To impart the theoretical and practical knowledge of climatic hazards and their mitigations.

Theory

UNIT I

Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters (hazards and vulnerabilities) suffered in the concerned continent/region/country/sub-region and their documented or remembered impacts; hazards and their relation to agricultural production risks (intra- and inter-annual); efforts made in mitigating impacts of (future) disasters (prevention); trends discernable in occurrence and character of disasters, if any.

UNIT II

Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns; history of present land use and cropping patterns in the continent/region/country/sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.

UNIT III

Recent trends in land use and cropping patterns; adoption of preparedness strategies - priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

UNIT IV

Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural production inputs and their history; determination of input efficiencies; other factors determining inputs and input efficiency; actual use of inputs in main land use and cropping patterns of the region.

UNIT V

Selection of livestock management: history of livestock management patterns in the continent/region/country/sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present livestock management strategies; outlook for present livestock management strategies and possible alternatives from an environmental point of view; recent trends in livestock management strategies.

UNIT VI

Adoption of microclimate modification techniques: review of microclimate management and manipulation methods; history of microclimate modification techniques practised in the continent/country/sub-region concerned; possible improvements in adoption of microclimate modification techniques, given increasing climate variability and climate change; local trends in adoption of such techniques.

UNIT VII

Protection measures against extreme climate: history of protection measures against extreme climate in the continent/region/country/sub-region concerned; successes and difficulties experienced by farmers with present protection measures; outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.

Practical

- Outlook for present land use and cropping patterns and possible alternatives from environmental point of view
- Recent trends in land use and cropping patterns
- Agro-meteorological services to increase farmers design abilities of land use and cropping patterns
- Systematic and standardized data collection on protection measures against extreme climate

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol.* UNEP, UNDP Publ.

Anonymous. *IPCC Assesment Reports on Climate Change Policy: Facts, Issues and Anlysis*. Cambridge Univ. Press.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Pretty J & Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.

Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.

Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

AGM 607 MATHEMATICS IN AGRICULTURE AND BIOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of mathematical concept in bioscience.

Theory

UNIT I

Functions: function of a single real variable; single-valued and many-valued functions; linear functions; power functions; polynomial functions; trigonometric, exponential and logarithmic functions; functions of several real variables.

UNIT II

Differentiation: derivative of the function of a single variable; derivatives of the functions of several variables-partial derivatives; maxima and minima; applications.

UNIT III

Integration: integrals of functions with respect to their independent variables; indefinite, definite and infinite integrals, applications.

UNIT IV

Ordinary differential equations: classification; solution of linear differential equations; applications; partial differential equations - classification, applications.

UNIT V

Vectors: rules of the game with the vectors; applications; matrices and determinants: characterization; rules of the game with matrices and determinants; systems of linear algebraic equations and their solutions; characteristic roots of matrices; applications.

UNIT VI

Methods of analysis: averaging and scaling methods, numerical analysis; finite element method, Monte Carlo analysis, spatial variability, stochastic methods, Fourier Analysis, perturbation; iterative and optimal techniques; applications.

UNIT VII

Probability: probability and probability distributions; applications.

Practical

- Use of simple log and semi-log graph papers
- Use of logarithms and logarithmic tables
- Plotting linear and log graph
- Trigonometric functions and relations
- Data representation as pie, bar and histograms
- Statistical data analysis-averages, standard deviations, simple correlation coefficient

Suggested Readings

Arya JC & Lardner RW.1979. *Mathematics for Biological Sciences.* Prentice Hall.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Crank J, Martin HG & Melluish DM. 1980. *Mathematics for Biological Sciences*, Oxford Univ. Press.

Eason G, Coles C, Wand Gettinby G. 1980. *Mathematics and Statistics for Biosciences*, Ellis Harwood Ltd.

Francis 1983. *Theory and Problems of Numerical Analysis*. McGraw Hill.

Hann CT. 1995. *Statistical Methods in Hydrology*. East-West Press.

Panse VG & Sukhatme PV. 1983. *Statistical Methods for Agricultural Workers*. ICAR.

Ramachery SKVS, Bhujanga Rao M & Bhandari S. 2000. *Engineering Mathematics.* IBS Publ.

Ray M & Sharma HS. 1970. *Mathematical Statistics*. Ram Prasad & Sons.

Vashistha AR. 1991. *Modern Algebra*. Krishna Prakashan Mandir.

AGM 608 DATABASE MANAGEMENT AND COMMERCIALIZATION OF AGROMETEOROLOGICAL DATA IN E-SERVICES 1+2

Objective

To impart knowledge on management of agromet data and train the students in commercialization of agrometeorological data through e-services.

Theory

UNIT I

Data and information; types of data; climate, soil and crop data; Importance of database management; data requirements; data collection and recording (Automatic and manual).

UNIT II

Data structure/format; quality control of data; techniques of climatic data generation; missing data; introduction to different software for database management.

UNIT III

Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research.

UNIT IV

Availability, accessibility and security of data; evaluating the cost of data; e-management of data.

Practical

- Types of instruments and data recording
- AWS data retrieval, storage and transfer
- Exposure to different software for Agromet data analysis; exposure to Statistical software
- Temporal and spatial analysis of data; exposure to GIS
- Value addition to data
- Introduction to internet protocols
- Uploading and downloading data, password and security of data
- E-management of data

Suggested Readings

Ghadekar R. 2002. *Practical Meteorology – Data Acquisition Techniques, Instruments and Methods*. 4th Ed. Agromet Publ.

IMD/ WHO. 1988. *Users Requirements for Agrometeorological Services*. IMD.

Miles MB & Huberman AM. 1994. *Qualitative Data Analysis*. Sage Publ.

Panse VG & Sukhatme PV. 1983. *Statistical Methods for Agricultural Workers*, ICAR.

Potter GB. 1994. *Data Processing: An Introduction*. Business Publ.

Ramakrishnan R. & Gehrke J. 2003. *Database Management System.* McGraw-Hill.

AGRICULTURAL METEOROLOGY

List of Journals

- Agricultural and Forest Meteorology
- Agricultural Systems
- Agricultural Systems and Information Technology Newsletter
- Agronomy Journal
- Atmospheric Research
- Canadian Water Resource Journal, Ottawa
- Climate Dynamics
- Climate Research
- Climatic Change
- Computers and Electronics in Agriculture
- Crop Science
- Ecological Modelling
- Environmental Monitoring and Assessment
- GIS India
- Hydrology Journal
- Indian Journal of Environmental Protection
- International Journal of Climatology
- International Journal of Remote Sensing
- Italian Journal of Agrometeorology
- Journal of Agricultural Meteorology
- Journal of Agrometeorology
- Journal of Applied Meteorology
- Journal of Applied Hydrology
- Journal of Applied Meteorology and Climatology
- Journal of Earth Systems Science
- Journal of Hydrologic Engineering
- Journal of Hydrometeorology
- Journal of Weather Modification Association
- Mausam
- Monthly Climatological Data for the World
- Photonirwachak
- Pollution Research
- Remote Sensing of Environment
- Vatavaran
- Vayu Mandal
- Water Resource Research
- Weather
- Weather and Forecasting
- WMO Bulletin

Suggested Broad Topics for Master's and Doctoral Research

- Microclimatic studies in crops and control climate
- Crop-weather interaction studies in field, vegetable and horticultural crops
- Crop-weather-pest interaction studies
- GIS approach in agro-ecological zoning and crop environment characterization
- Testing and validation of various existing crop simulation models to determine the production potentials in different regions of the state for major crops
- Climate change and sustainability –regional scenarios
- Weather modification studies
- Development of weather based model for major crops of the state
- The crop acreage and yield estimates for state using remote sensing approach
- Studies involving the ground-based spectral signatures for stress detection and yield modeling of important crops in the state
- Weather-based agro advisories, impact assessment and related issues
- Impact assessment studies in livestock and other agricultural production systems
- Evapo-transpiration studies using different approaches
- Extreme weather events, their impact on agriculture and their alleviation
- Agro-climatic resource characterization with reference to crops
- Crop-weather relationship for major crops
- Crop-growth simulation modeling
- Development of weather-based forewarning models for pest and disease
  Impact of climate change on agriculture
- Application model based agro-advisories to farmers
- Application of remote sensing in large scale crop condition assessment and yield prediction

AGRICULTURAL PHYSICS
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
AP 501*	FUNDAMENTALS OF SOIL PHYSICS	2+1
AP 502*	FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY	2+1
AP 503*	PRINCIPLES OF BIOPHYSICS	2+1
AP 504*	PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE	2+1
AP 505	PHYSICS OF SOIL AND WATER CONSERVATION	2+1
AP 506	SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH	2+1
AP 507	ANALYTICAL TOOLS AND METHODS FOR AGROMETEOROLOGY	2+1
AP 508	WATER- NUTRIENT DYNAMICS IN UNSATURATED ZONE	3+1
AP 509	PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE	3+1
AP 510	PRINCIPLES AND APPLICATIONS OF GIS AND GPS	2+1
AP 511	NUCLEAR TECHNIQUES IN AGRICULTURE AND BIOLOGY	2+1
AP 591	MASTER'S SEMINAR	1+0
AP 599	MASTER'S RESEARCH	20
AP 601	PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE	3+0
AP 602	TRANSPORT PROCESSES IN SOILS	3+0
AP 603	MODELLING SOIL PHYSICAL PROCESSES	2+0
AP 604	CROP MICROMETEREOLOGY	2+1
AP 605	EVAPOTRANSPIRATION	2+1
AP 606	CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT	2+1
AP 607	WATERSHED MANAGEMENT	1+0
AP 691	DOCTORAL SEMINAR I	1+0
AP 692	DOCTORAL SEMINAR II	1+0
AP 699	DOCTORAL RESEARCH	45

*Compulsory for Master's Programme

Suggested Supporting courses

AP 511	Mathematics in Agriculture	(2+0)
AP 512	Basic Concepts of Physics	(2+1)

AGRICULTURAL PHYSICS
Course Contents

AP 501 FUNDAMENTALS OF SOIL PHYSICS 2+1

Objective

To impart theoretical and practical knowledge about soil physical properties and processes occurring in soils.

Theory

UNIT I

Soil as a disperse poly-phase system; mass-volume relationships of soil constituents; sample problems.

UNIT II

Soil texture; nature and behaviour of soil particles; textural classes; particle-size analysis.

UNIT III

Soil structure- genesis, classification and evaluation; soil aggregation and dispersion; soil conditioners; soil tilth.

UNIT IV

Consistency; consistency limits; soil strength and its measurement; swelling and shrinkage; soil compaction; soil crusting; phenomenon and implications.

UNIT V

Soil water retention; soil water constants; energy concept of soil water; different components of soil water potential; measurement of soil water content and potential; soil-moisture characteristics; hysteresis.

UNIT VI

Flow of water in soils; saturated and unsaturated flow; hydraulic conductivity of soils; soil-water diffusivity; measurement of saturated and unsaturated hydraulic conductivity.

UNIT VII

Infiltration, redistribution and evaporation of water; soil water balance; permeability; drainage.

UNIT VIII

Soil aeration and its characterization; measurement of soil aeration; gaseous diffusion; factors affecting.

UNIT IX

Soil temperature and significance; thermal properties of soils; energy balance and mode of heat transfer in soils; factors affecting soil temperature; measurement of soil temperature; management of extreme soil temperatures.

Practical

- Particle-size analysis by hydrometer method and international pipette method
- Determination of particle density and bulk density of soils
- Soil water content determinations
- Measurement of soil water potential by using tensiometer
- Soil-moisture characteristics
- Aggregate analysis by wet and dry sieving methods
- Measurement of Atterberg limits

- Measurement of soil strength
- Determination of saturated and unsaturated hydraulic conductivity
- Determination of infiltration rates

Suggested Readings

Black CA. 1965. *Methods of Soil Analysis*, Part I. American Society of Agronomy, Madison.

Brady NC. 1996. *Nature and Properties of Soils*. 10th Ed. Prentice Hall of India.

Ghildyal BP & Tripathi RP. 1987. *Soil Physics*. Wiley Eastern & New Age International.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.

Singh RA. 1980. *Soil Physical Analysis*. Kalyani.

AP 502 FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY 2+1

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in Meteorology.

Theory

UNIT I

Solar radiation and laws of radiation; greenhouse effect; albedo and heat balance of the earth and atmosphere; variation of pressure and temperature with height; potential temperature, pressure gradient, cyclonic and anti-cyclonic motions; geostrophic and gradient winds; equations of motion, general circulation, turbulence, vorticity atmospheric waves.

UNIT II

Gas laws; laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere; humidity parameters and their inter-relationships; vapour pressure; psychrometric equation; saturation deficit; stability and instability conditions in the atmosphere.

UNIT III

Lapse rates - ascent of dry and moist air; condensation; clouds and their classification; hydrological cycle; precipitation processes; artificial rainmaking; thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT IV

Effect of earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon.

UNIT V

Weather charts, forecasting methods - short, medium and long range forecasting techniques; numerical weather prediction; EL Nino and Southern oscillations and its impact on drought.

UNIT VI

Instruments for measurement of meteorological elements; agromet observatory; measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function,

water budgeting; synoptic numerical, graphical, spatial analysis of weather systems and charts technique.

Practical

- Agromet observatory - different classes of observatories (A, B, C): site selection and installation procedures for meteorological instruments
- Measurement of weather parameters
- Calculation of daily, weekly, monthly meteorological data, climatic normals, and preparation of weather charts
- Statistical techniques for commutation of normals, moving average, marton chain model etc.
- Morphological observations involving use of optical microscopic methods under red, blue and green illuminations
- Transmittance/absorbency of light through coloured solutions using spectrophotometers/photometers covering visible, near infra red and ultra violet spectra regions

Suggested Readings

Barry RG & Richard JC. 2003. *Atmosphere, Weather and Climate*. Tailor & Fransics.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Byers HR. 1959. *General Meteorology*. McGraw Hill.

Ghadekar SR. 1991. *Meteorology*. Agromet Publ.

Mcllveen R. 1992. *Fundamentals of Weather and Climate*. Chapman & Hall.

Petterson S. 1958. *Introduction to Meteorology*. McGraw Hill.

Trewartha GT. 1954. *An Introduction to Climate*. McGraw Hill.

AP 503 PRINCIPLES OF BIOPHYSICS 2+1

Objective

To impart theoretical and practical knowledge of different life forms, and interactive effects of various physical forces on life processes.

Theory

UNIT I

Scope of biophysics; weak and strong interactions in biological systems; physical, chemical and biological origin of life.

UNIT II

Structure and function of biological macromolecules and their organization; unicellular and multi-cellular life forms; types of specialized cells and their functions; cell to cell communication.

UNIT III

Structure of plant and animal cell and membranes; basis for cell membrane voltages, bioelectricity of cell membrane and measurement; artificial membranes.

UNIT IV

Amino acids and peptides; protein structure, primary and secondary structure; nucleic acids; mechanism of genetic control; polysaccharides; lipids.

UNIT V

Electrophysiology; nature and identification of plant and animal viruses.

UNIT VI

Bioenergetics; types of binding forces; laws of thermodynamics; negative entropy and information theory.

UNIT VII

Experimental techniques used for the separation and characterization of biomolecules; sedimentation, ultracentrifugation, electrophoresis, chromatography, amino acid and nucleotide sequence analysis; diffusion, osmometry, viscometry, polarimeter, GLC, HPLC.

UNIT VIII

Transport phenomenon in biological systems - simple, active and passive transport.

Practical

- Sample component separation by various physical techniques-sedimentation, centrifugation, electrophoresis, chromatography (liquid/paper)
- Optical rotation by sugars using polarimeter
- DNA separation by chemical method; identification of plant viruses by electron microscope

Suggested Readings

Birnie GD & Rickwood R. 1978. *Centrifugal Separations in Molecular and Cell Biology*. Butterworths.

Cambell GS. 1977. *An Introduction to Environmental Biophysics*, Springer Verlag.

Casey EJ. 1962. *Biophysics, Concepts and Mechanisms*. Van Nostrand Reinhold.

Daniel M. 2005. *Basic Biophysics for Biologists*. Agrobios.

Elasser WM. 1958. *The Physical Foundations of Biology, An Analytical Study*. Pergamon Press.

Glick D. (Ed.). 1967. *Methods of Biochemical Analysis*. Vol. XV. Interscience.

Hoppe W, Lohmann W, Mark H & Hubert Z. 1983. *Biophysics.* Springer Verlag.

Narayanan P. 2003. *Essentials of Biophysics*. New Age International.

Neuhoff V. 1973. *Molecular Biology, Biochemistry*. Vol. XIV. Chapman & Hall.

Pain RH & Smith BJ. (Eds.). 1975. *New Techniques in Biophysics and Cell Biology*. Wiley.

Rasevsky N. 1960. *Mathematical Biophysics, Physico-Mathematical Foundations of Biology.* Vol. II. Dover Publ.

Thimmaiah SK. 2004. *Standard Methods of Biochemical Analysis*. Kalyani.

Wilson K & Walker J. 2004. *Practical Biochemistry Principles and Techniques*. Cambridge Univ. Press.

AP 504 PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE 2+1

Objective

To educate about different optical, electrical, colorimetric and nuclear techniques used in agriculture.

Theory

UNIT I

Principles of measurements; laboratory, field and regional scales.

UNIT II

Principles of optical and polarized microscopes; reflection, transmission and absorption in relation to properties of object; colorimetric techniques; single and double beam instruments; spectrophotometry; Beer and Lambert law; fluroscence; Raman spectra.

UNIT III

Sensors and transducers; principles of leaf area meter, canopy analyzer, quantum sensor, spectro-radiometer, laser land leveler; photosynthetic system analyzer for determination of plant water and photosynthetic parameters.

UNIT IV

Principles of infrared thermometry; emissivity laws; characteristics of agricultural materials.

UNIT V

Principles of X-ray and its applications in clay mineralogy; small angle scattering.

UNIT VI

Principles and applications of electron microscopes; transmission and scanning electron microscopes; confocal microscope and its applications.

UNIT VII

Atomic absorption spectroscopy - principles, detection limits and sensitivity.

UNIT VIII

Nuclear techniques - detection and measurements of charged particles, radiation monitoring instruments, radiation hazards evaluation and protection.

UNIT IX

Tracer methodology - isotopes and their applications in agriculture, gamma irradiation for genetic variability.

UNIT X

NMR, mass spectrometer - principles and applications.

Practical

- Discharge of electricity through gases
- Ionization current measurements
- Photoelectric effect and measurements
- Geiger Muller counter- quenching time
- Thickness measurement of thin films/foils/paper sheets
- Half-life determination
- Tracer applications of artificial radionuclides
- Multi-channel analyser
- Neutron moisture meter
- Use of NMR spectrometer
- Seed irradiation with gamma rays
- Radiocarbon dating.

Suggested Readings

Arnikar HJ. 1989. *Isotopes in the Atomic Age*. Wiley Eastern.

Bhaskaran S, Ghosh SK & Sethi GR. 1973. *Proceedings of the International Symposium on Use of Isotopes and Radiation in Agriculture and Animal Husbandry Research,* Nuclear Research Laboratory, IARI, New Delhi.

Broetjes C. 1965. *The Use of Induced Mutations in Plant Breeding*. Pergamon Press.

Burcham E. 1995. *Nuclear Physics*. ELBS/Longman.

Glasstone S. 1967. *Source Book of Atomic Energy*. Affiliated East West Press.

Kapoor SS & Ramamurthy VS. 1986. *Nuclear Radiation Detectors*. Wiley Eastern.

Pochin E. 1983. *Nuclear Radiation: Risks and Benefits*. Clarendon Press.

Rajan JB. 2000. *Atomic Physics*. S Chand & Co.

Tiwari PN. 1985. *Nuclear Techniques in Agriculture*. Wiley Eastern.

Wolf G. 1964. *Isotopes in Biology*. Academic Press.

AP 505 PHYSICS OF SOIL AND WATER CONSERVATION 2+1

Objective

To teach about extent and significance of different forms of soil erosion and their control measures.

Theory

UNIT I

History of soil erosion; geological and accelerated erosion; agents of soil erosion; acceptable limits of soil erosion.

UNIT II

Physics of soil erosion by water; types of water erosion - sheet erosion, splash erosion, rill erosion, gully erosion; specialized forms of soil erosion-pedestal erosion, pinnacle erosion, piping, slumping.

UNIT III

Soil erodibility; factors affecting soil erodibility - soil physical characteristics, land management, crop management; soil erodibility inidices; empirical constants.

UNIT IV

Rainfall erosivity; estimation of rainfall erosivity - EI_{30} index and kinetic energy, and their calculations; erosivity indices.

UNIT V

Runoff measurements – current meters, flumes, weirs and orifice, stage level recorder, hydrographs; runoff estimation - quantities and rates of runoff, Rational formula, Cook's method.

UNIT VI

Sediment measurement - multislot divisor, Coshocton wheel sampler, point and depth integrated sediment samplers; universal soil loss equation; estimation of soil loss and its prediction.

UNIT VII

Physics of wind erosion - wind velocity, initiation and movement of soil particles; saltation, suspension and surface creep; soil physical properties affecting wind erosion.

UNIT VIII

Overview of soil and water conservation in India; soil and water conservation research; techniques for soil and water conservation for

agricultural and non-agricultural land - use of mechanical structures and biological methods; wind erosion control.

UNIT IX

Concept of watershed development and management - size and shape of watershed; characterization and management of watersheds using remote sensing and GIS; understanding concept of integrated watershed management through case studies.

Practical

- Determination of soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index; computation of kinetic energy of falling rain drops
- Measurement of land slope using Abney's level
- Computation of rainfall erosivity index (EI_{30}) using rain gauge data
- Estimation of surface runoff/water flow using different techniques
- Estimation of soil losses
- Visit to a watershed

Suggested Readings

Fangmeier DD, Elliot WF, Wookman SR, Huffman RL & Schwab GO. 2006. *Soil and Water Conservation Engineering*. Delmer Learning.

Flanagan DC. (Ed.).1990. *WEPP* Second Edition, USDA-Water Erosion Prediction Project; Hill Slope Profile Model Documentation Corrections and Additions. NSERL Rpt. No. 4. National Soil Erosion Res. Services, USDA.

Gurmel Singh, Ram Babu & Subhas Chandra. 1981. *Soil Loss Prediction Research in India*. Central Soil & Water Conservation Research & Training Institute, Dehradun. Bull. No.T12/D9.

Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.

Pierce FJ & Frge WW. 1998. *Advances in Soil and Water Conservation*. CRC Press.

Renald KG, Foster GR., Weesies GA, Cool DK & Yoder DC. 2000. *Predictory Soil Erosion by Water*: *A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE).* Agricultural Handbook AH 703.USDA.

AP 506 SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH 2+1

Objective

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

Theory

UNIT I

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

UNIT II

Characterization of root growth parameters; hydraulic properties of roots; root uptake of soil moisture; flow of water to roots; nutrient uptake by plants.

UNIT III

Plant-water relations - SPAC; plant available water, newer concepts of water availability; least limiting water range; xylem and leaf water

potential; water movement through plants; potential and actual transpiration, their determination and estimation - Pennman-Monteith equation; evapotranspiration and plant growth.

UNIT IV

Soil meachanical impedance - factors affecting and characterization; mechanical impedance and root/shoot growth; management options - tillage.

UNIT V

Soil aeration status and root/shoot growth; soil crusting - factors affecting, effect on root/shoot growth and its amelioration; clod formation-mechanism, significance and management options; structural management of rice soils; soil conditioners as modifiers of soil structure.

UNIT VI

Root/shoot growth in relation to soil thermal regimes; modification of soil thermal regimes - irrigation, mulching, tillage.

UNIT VII

Nutrient uptake by plants; integrated nutrient management - significance, prospectus and constraints; organic farming - concept, soil physical productivity.

UNIT VIII

Field water balance, consumptive water use, transpiration ratio, water use efficiency, water productivity; hi-tech irrigation techniques to improve water use efficiency.

UNIT IX

Modeling of soil, climatic and management factors for plant growth; development of system sustainability indices.

Practical

- Determination of plant-available water content
- Determination of least-limiting water range
- Use of psychrometer for measurement of water potential
- Estimation of evapo-transpiration losses under different management options
- Measurement/estimation of consumptive water use, production functions, field water balance components, water uptake by plants, leaf and xylem water potential
- Determination of components of water balance in a cropped field

Suggested Readings

Doorenbos J & Pruitt WO. 1975. *Crop Water Requirements*. FAO Irrigation and Drainage Paper 24. Rome.

Hanks & Ascheroft. 1980. *Applied Soil Physics*. SpringerVerlag.

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

Hillel D. 1998. *Environmental Soil Physics*. Academic Press.

Slatyer RO. 1967. *Plant- Water Relations*. Academic Press.

AP 507 ANALYTICAL TOOLS AND METHODS FOR AGROMETEOROLOGY 2+1

Objective

To teach about principles and methodology of different instruments and techniques used in meteorological studies.

Theory

UNIT I

Review of agroclimatic methods; characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.

UNIT II

Network spacing; spatial and temporal methods; GIS fundamentals and application; numerical characterization of climatic features; crop response to climate, time lags, time and distance constants, hysteresis effects, influence of climate on stress-response relations.

UNIT III

Thermal time approach in agroclimatology - heat unit system, thermal time, heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction; comfort indices for human and animals.

UNIT IV

Instrumentation and sampling problems; design of agro-meteorological experiments; data processing techniques in agroclimatology - synotptic, numerical and graphical techniques, spatial analysis of weather systems and charts.

UNIT V

Empirical and statistical crop weather models and their application with examples; incorporating weather, soil, plants and other environment-related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation models; forecasting models for insects and diseases.

Practical

- Calculation of continental factors for quick assessment
- Climatic indices and climogram
- Agro-meteorological indices - degree-days, photothermal units, heliothermal units, phenothermal index
- Heat use efficiency of crops
- Analysis of thermogram, hygrogram, hyetogram, sunshine cards etc.
- Preparation and analysis of isobar and isothermal charts
- Stream lines and wind roses and statistical analysis of climatic data
- Working with statistical models - crop yield forecasting, crop weather relationship and insect & disease forecasting models
- Working with crop simulation models

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Conrad V & Pollak LW. 1950. *Methods in Climatology*. Harvard Univ. Press.

Cooper M. 2006. *The Spirit of C. An Introduction to Modern Programming*. Jaico Publ.

IMD/WHO. 1998. *Users Requirements for Agrometeorological Services*. IMD.

Malczewski J. 1999. *GIS & Mulicriteria Decision Analysis*. John Wiley & Sons.

Munn RE. 1970. *Biometeorological Methods*. Academic Press.

Thom HCS. 1971. *Some Methods of Climatological Analysis*. W.M.O. Technical Note No. 81, W.M.O. Geneva.

AP 508 WATER-NUTRIENT DYNAMICS IN UNSATURATED ZONE 3+1

Objective

To teach about principles of water and nutrient transport processes involved in unsaturated soil conditions.

Theory

UNIT I

Unsaturated zone - the vadose zone- characterization; subdivision of unsaturated zone.

UNIT II

Saturated and unsaturated flows; Buckinghum-Darcy equation and Richard's equation; unsaturated flow parameters; relation of conductivity to suction and wetness; diffusivity; Boltzman transformation; laboratory and field measurements of hydraulic conductivity and diffusivity; introduction to numerical solutions of water flow equations; vapour movement.

UNIT III

Soil structural problems of unsaturated zone and their amelioration and management; soil quality and soil resilience.

UNIT IV

Components of water balance equation and methods of computation; scaling of soil water phenomena; ground water and surface water relationships; drainage.

UNIT V

The physics of infiltration, vertical infiltration, Green-Ampt model, Philip's model; homogeneous and layered soil infiltration, horizontal infiltration; evaporation - methods of computing evaporation; contribution of deeper layers; preferential flow of water.

UNIT VI

Convective transport of solutes; diffusion of solutes; hydrodynamic dispersion; miscible displacement and breakthrough curves; advection-dispersion equation (ADE) for non-adsorbed solutes; solute transport parameters; ADE for linear and non-linear adsorption of solutes; solutions of ADE equation - Laplace transformation, analytical and numerical solutions; equilibrium and non-equilibrium transport.

UNIT VII

Soil irrigability indices; irrigation-induced salinity process; dry-land salinity process; modification of unsaturated root zone for optimal soil physical conditions.

Practical

- Determination of hydraulic conductivity of unsaturated zone by auger hole method
- Quantification of layer-wise contribution to water fluxes between two irrigation cycles
- Estimation of capillary rise/ drainage flux in the unsaturated zone
- Study of movement of contaminants in unsaturated zone in agricultural farm
- Study of ground water pollution in agricultural farm

Suggested Readings

Hillel D. 1998. *Environmental Soil Physics*. Academic Press.

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

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.

Kurt Roth 1996. *Lecture Notes in Soil Physics*. Institute of Soil Science, Univ. of IIohenheim.

Nye PH & Tinker PB. 1977. *Solute Movement in the Soil Root System*. Blackwell Scientific.

AP 509 PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE 2+1

Objective

To teach about principles and practices involved in remote sensing, and their application in agriculture.

Theory

UNIT I

Basic components of remote sensing - signals, sensors and sensing systems; active and passive remote sensing.

UNIT II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

UNIT III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensors platforms, their launching and maintenance.

UNIT IV

Data acquisition system, data pre-processing, storage and dissemination; digital image processing and information extraction; microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

UNIT V

Digital techniques for crop discrimination and identification; crop stress detection- soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature; monitoring of crop disease and pest infestation.

UNIT VI

Drought monitoring; soil resource inventory; land use/land cover mapping and planning; integrated watershed development.

UNIT VII

Crop yield modeling and crop yield forecasting.

Practical

- Use of spectro-radiometer
- Spectral signatures of different soils and crops
- Spectral indices derivation from data
- Infrared and spectral data for crop stress monitoring
- Stress indices derivation
- Spectral indices for crop discrimination and crop growth dynamics
- Derivations of drought indices from satellite data

- Salinity mapping from remote sensing data
- Digital image processing - introduction to softwares, preprocessing, enhancement and training sites collection and classification and post-classification accuracy assessment
- Analysis of high resolution data and time series data for soil and crop characterization
- Land use land covers classification and change detection.

Suggested Readings

Campbell JB. 1996. *Introduction to Remote Sensing*. The Guilford Press.

Colwell RN. (Ed.). 1983. *Manual of Remote Sensing*, Vols. 1, II. Am. Soc. Photogrammetry, Virginia.

Curan PJ. 1985. *Principles of Remote Sensing*. ELBS/Longman.

David L Verbyla. 1995. *Satellite Remote Sensing of Natural Resources.* Taylor & Francis.

George Joseph. 2005. *Fundamentals of Remote Sensing*. University Press (India).

Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.

Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.

Patel AN & Surender Singh. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

AP 510 PRINCIPLES AND APPLICATIONS OF GIS AND GPS 2+1

Objective

To educate about basics of GIS and GPS systems, and their application in agricultural research

Theory

UNIT I

Introduction, history, basic concepts, principles, techniques, procedures and terminology of geographic information systems; geographical data types/models

UNIT II

Data characteristics and management - RDBMS, technical aspects of GIS data collection; linking spatial and non-spatial data; errors and quality control; data output

UNIT III

Map projections - basic Geodesy Geiod /Datum/Ellipsoid, Co-ordinate systems, scale factor, distortions, classification of map projections, transformations, surveying

UNIT IV

Raster-based GIS - spatial referencing, definition and representation, data structure, advantages and disadvantages; vector based GIS - definition, concept, data structure, capture and vector and raster formats; vector to raster and raster to vector conversion, advantages and disadvantages

UNIT V

Principles of graph theory, topology and geometry

UNIT VI

Spatial Analysis - statistical analysis, measurement, proximity (buffering), overlay analysis, classification, network analysis; multi-criteria analysis; site suitability analysis; nearest neighbour analysis; Thiessen polygon,

surface mapping, interpolation, DEM, geo-statistical analysis, spatial and non-spatial query

UNIT VII

Software and hardware requirements of GIS; interface between GIS and RS; GIS for modeling

UNIT VIII

Trends in GIS - web GIS, 3D GIS, object-oriented GIS, mobile GIS, knowledge-based GIS; data warehousing, data mining, met-data, data interoperability, open GIS consortium, GIS customization, DSS and SDSS

UNIT IX

Applications of GIS - watershed development, disaster management, terrain analysis, agriculture, biodiversity, precision farming, e-governance, agricultural research information system etc

UNIT X

Basic concepts of GPS, space segment, control segment, user's segment; working principles of GPS; measuring distance and timing; errors in GPS data and correction; differential GPS; integration of GPS data with GIS data; use of GPS in remote sensing analysis; past, present and future status of GPS; applications of GPS in agriculture and natural resource management

Practical

- Soft wares and hard wares requirement of GIS analysis
- Overview of ARC VIEW soft wares
- Overview of ARC GIS
- Overview of SPANS/ GEOMATICA
- Scanning and registration of base maps
- Use of GPS, integration with RS data and GIS
- Digitizing, editing and error correction
- Attaching attribute data
- Preparation of thematic maps, overlaying
- Query building
- Overview of IDRISI-Raster GIS

Suggested Readings

Anji Reddy M. 2006. *Textbook of Remote Sensing and Geographical Information System*. BS Publ.

Antenucci JC, Brown K, Croswell PL, Kevani E & Archer H. 1991. *Geographic Information Systems: A Guide to the Technology.* Chapman & Hall.

Bernhardsen T. 1999. *Geographic Information Systems: An Introduction.* Wiley.

Burrough PA & Mcdonell RA. 1997. *Principles of Geographic Information Systems*. Oxford Univ. Press.

Chakraborty D & Sahoo RN. 2004. *Fundamentals of Geographic Information Systems*. Viva Books.

Chrisman N. 2002. *Exploring Geographic Information Systems*. John Wiley & Sons.

Heywood I, Cornelius S & Carver SJ. 2006. *An Introduction to Geographical Information Systems*. 3rd Ed. Prentice Hall.

Jan Van Sickle. 2004. *Basic GIS Coordinates*. CRC Press.

Lakham VC. 2003. *Introductory Geographic Information Systems.* Summit Press.

Laurini R & Thompson D. 1996. *Fundamentals of Spatial Information System*. Academic Press.

Maguire DJ. *et al*. (Eds.). 1991. *Geographic Information Systems: Principles and Applications*. Longman House.

Michael N DeMers. 2005. *Fundamentals of Geographic Information System*. 2nd Ed. John Wiley & Sons.

Star J. & Estes J. 1990. *Geographic Information Systems: An Introduction.* Prentice Hall.

AP 511 NUCLEAR TECHNIQUES IN AGRICULTURE AND BIOLOGY 2+1

Objective

To teach students about different sources of radiation, and their application in agricultural and biology studies.

Theory

UNIT I

Structure of atom; atomic nucleus - its constituents, structure and stability, nuclear forces and energetic; mass formula.

UNIT II

Radioactivity- natural, artificial and induced; characteristics of alpha, beta and gamma radiations; law of radio active disintegration, half life, radio activity in a mixture of different radionuclides; radioactive equilibria (secular and transient); units of radio activity.

UNIT III

Interactions of nuclear radiations with matter; detection and measurement of nuclear radiations; Geiger-Muller counter, solid and liquid scintillation counters, nuclear emulsions.

UNIT IV

Nuclear reactors - fission, fusion and breeder reactors; particle accelerators; detection and measurement of stable isotopes.

UNIT V

Concepts of isotope tracer methodology, isotopic tracer applications in micronutrient studies; autoradiography; nuclear techniques as analytical tools- activation analysis, Mossbauer and NMR spectroscopic applications in agriculture, gamma probe and neutron moisture meter.

UNIT VI

Low level radiation in agriculture, and biology, radiation hormesis, radiation-induced phenomena; food irradiation; radiation protection; radio active waste disposals; radiation safety; storage of radio-active material, its handling, use of monitors, masks, regulations and safety measures.

Practical

- Discharge of electricity through gases
- Ionization current measurements
- Photoelectric effect and measurements
- Geiger Muller counter- quenching time
- Thickness measurement of thin films/foils/paper sheets
- Half-life determination
- Tracer applications of artificial radio nuclides

- Multi-channel analyzer
- Neutron moisture meter
- Use of NMR spectrometer
- Seed irradiation with gamma rays
- Radiocarbon dating
- Hands on exposure to radiation safety

Suggested Readings

Arnikar HJ. 11989. *Isotopes in the Atomic Age*. Wiley Eastern.

Bhaskaran S, Ghosh SK & Sethi GR. 1973. *Proc. of the International Symposium on Use of Isotopes and Radiation in Agriculture and Animal Husbandry Research*. NRL, IARI, New Delhi.

Broetjes C. 1965. *The Use of Induced Mutations in Plant Breeding*. Pergamon Press.

Burcham E. 1995. *Nuclear Physics*. ELBS/Longman.

Glasstone Samuel 1967. *Source Book of Atomic Energy*. Affiliated East West Press.

Kap0or SS & Ramamurthy VS. 1986. *Nuclear Radiation Detectors*. Wiley Eastern.

Pochin. E. 1983. *Nuclear Radiation: Risks and Benefits*. Clarendon Press.

Rajam JB. 2000. *Atomic Physics*. S. Chand & Co.

Tiwari PN. 1985. *Nuclear Techniques in Agriculture*. Wiley Eastern.

Wolf G. 1964. *Isotopes in Biology*. Academic Press.

AP 601 PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE 3+0

Objective

To educate students about different types of radiations, their principles, characteristics and use in agricultural studies.

Theory

UNIT I

Electromagnetic spectrum; energy sources and their characteristics; spectral distribution of radiant energy; energy content in different radiations.

UNIT II

Radiation units, flux, intensity, emittance, inter-conversion of radiometric units.

UNIT III

Radiation principles, resolution, geometry considerations, solid angle concept, interconversion of photometric units.

UNIT IV

Intercation of radiation with matter, scattering, reflection, transmission, absorption, diffuse and speculr radiations.

UNIT V

Photosynthetically active radiation, Einstein mole, photon units and their inter-conversion, colour designations.

UNIT VI

Conversion of optical to thermal and other forms of energy; thermal radiation, blackbody radiation, Kirchoff's law.

UNIT VII

Microwave radiations; dielectric constant; microwave energy dissipation in interacting materials, isotropic and non-isotropic mediums; microwave transmission, reflection, polarization; microwave and radiowave heating.

UNIT VIII

Ionizing and non-ionizing radiations; applications in agriculture and biology; energy balance of land surfaces, energy budget of leaf, energy budget of crop canopy; radiation interception.

Suggested Readings

Ghadekar SPA. 2001. *Text Book of Agrometeorology*. Agromet Publ.

Haliday.1966. *University Physics*. Academic Press.

Mavi HS & Tupper GJ. 1993. *Agrometeorology - Principles and Applications of Climatic Studies in Agriculture*. Food Products Press.

Minteith JL & Unsworth MH. 2008. *Principles of Environmental Physics*. Academic Press

Nelkon M & Parker P. 1987. *Advanced Level Physics*. 6th Ed. Arnold-Heinemann.

Panda BC. 2005. *Remote Sensing: Principles and Application*. Viva Books.

AP 602 TRANSPORT PROCESSES IN SOILS 3+0

Objective

To impart basic knowledge about different transport processes involving water, air, temperature, salts and chemical pollutants in soils and other porous media.

Theory

UNIT I

Theory of transport in soils; generalized approaches based on continuum mechanics and thermodynamics of irreversible processes; motion in tube with laminar flow, field scales and effective parameters, homogeneous porous medium.

UNIT II

Water: stationary flow of water, water flow in saturated soil, Darcy's law, Laplace equation, solutions to Laplace equation, Euler's theorem, water flow in unsaturated soil, parameterization of unsaturated hydraulic conductivity, hydraulic functions for typical soil textures, equation for transient flow of water, dynamics of water flow, stationary water flux, diffusivity, Boltzmann transformation and a wetting front, methods of measuring saturated and unsaturated hydraulic parameters.

UNIT III

Nutrients and salts: physical processes of the movement of solutes, diffusion, mass flow, convection, root interception, convective dispersive equation (CDE), miscible and immiscible displacement, hypothetical and experimental breakthrough curves, dynamics of solute transport, solutions and applicability of CDE, methods of determination of dispersion and diffusion coefficients, solute transport during infiltration.

UNIT IV

Heat: measurement of thermal diffusivity and conductivity, ground heat flux and soil temperature, determination of heat flux in soil, flow of water by heat action.

UNIT V

Air: gas movement and exchange, gaseous diffusion, equations for soil and air, methods of measuring gaseous diffusion coefficient, steady state and transient state gaseous diffusion, oxygen diffusion rate.

UNIT VI

Contaminants: sorption, degradation and fate of agrochemicals in soil, chemicals with linear, nonlinear and kinetic interactions of stable and unstable chemicals, numerical solutions.

Suggested Readings

Bird RB, Stewart WE & Lightfoot EN. 1979. *Transport Phenomenon*. John Wiley & Sons.

Hillel D. 1998. *Environmental Soil Physics*.Academic Press.

IHAR (Inter Association for Hydraulic Research) 1972. *Fundamentals of Transport Phenomenon in Porous Media*. Elsevier.

Milburn JA. 1979. *Water Flow in Plants (Integrated Theme in Biology).* Longman.

Nerpin SV & Chudnovskii AF. 1984. *Heat and Mass Transfer in the Plant-Soil-Air System*. Oxonian Press.

Warrick AW. 2002. *Soil Physics Companion*. CRC Press.

AP 603 MODELING SOIL PHYSICAL PROCESSES 2+0

Objective

To teach about theoretical models for predicting water and salt transport processes in soils.

Theory

UNIT I

Mathematical tools, Gaussian random variables, density and distribution functions, central limit theorem, generalized functions.

UNIT II

Modeling potential and limitations, modeling physical systems, conservation equation, flux law, dynamics, systems at equilibrium.

UNIT III

Numerical approximation, finite differences, finite elements, finite difference model of steady state.

UNIT IV

Saturated and unsteady unsaturated flow, applicability of numerical approximations, stationary flow and infiltration in homogeneous and heterogeneous soil.

UNIT V

Mathematical models for miscible displacement, solution for dispersion equation, mathematical dispersion models, and analytical solutions for ion transport.

UNIT VI

Modeling water uptake by roots under water and salinity stresses; modeling water erosion, soil erosion; modeling nutrient and contaminant dynamics; interconnectivity of different models.

Suggested Readings

Benbi DK & Nieder R. 2003. *Handbook of Processes and Modeling in the Soil-Plant System.* Food Products Process.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
Kurt Roth 1996. *Lecture Notes in Soil Physics*. Institute of Soil Science, Univ. of IIohenheim.
Warrick AW. 2002. *Soil Physics Companion*. CRC Press.

AP 604 CROP MICROMETEREOLOGY 2+1

Objective

To educate about principles of micrometeorology of crop canopy and atmosphere adjoining earth's surface and its impact on crop growth and yield.

Theory

UNIT I

Properties of atmosphere near the earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere; exchange coefficient, similarity hypothesis, shearing stress, force and free convection.

UNIT II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; temperature instability, air pollution.

UNIT III

Microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions; soil moisture and temperature variation with depth.

UNIT IV

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; radiation distribution and utilization by plant communities, leaf temperature and its biological effects.

UNIT V

Modification of microclimate due to cultural practices, intercropping; influence of topography on microclimate, shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

UNIT VI

Effects of ambient weather conditions on growth, development and yield of crops; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in short and tall crops; energy balance over crops, LAI and biomass estimation.

UNIT VII

Practical measurement of global radiation and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels.

Practical

- Measurement of global radiation and diffusion radiation
- Measurement of albedo over natural surfaces and cropped surfaces
- Measurement of net radiation at different levels
- PAR distribution in plant canopies and interception
- Wind, temperature and humidity profiles in short and tall crops

- Biomass estimation, quantification of crop microclimate, ET determination, calculations by different approaches

Suggested Readings

Chang JH. 1968. *Climate and Agriculture*. Aldine Publ.

Gopalaswamy N. 1994. *Agricultural Meteorology*. Rawal Publ.

Mavi HS. 1994. Introduction to Agricultural Meteorology. Oxford & IBH.

Peterson S. 1958. *Introduction to Meteorology*. McGraw Hill.

Rosenburg NJ. 1974. *Microclimate. The Biological Environment*. John Wiley & Sons.

AP 605 EVAPOTRANSPIRATION 2+1

Objective

To impart theoretical and practical knowledge about evapotranspiration process, its relationship with weather elements and its impact on plant growth.

Theory

UNIT I

Basic laws of radiation; radiation interaction with plant environment; energy balance in atmosphere, crop canopy.

UNIT II

Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.

UNIT III

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration; lysimetric techniques in measuring actual evapotranspiration; influence of microclimatic, plant, soil and cultural factors; relationship between actual and computed crop factor.

UNIT IV

Yield functions, water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and anti-transpirants, Kc values and its use, dry matter yield ET functions.

UNIT V

Radiation instruments; advanced techniques for measurement of radiation and energy balance; computation of K_C values and their use.

UNIT VI

Estimation of evapotranspiration through satellite imageries – MODIS, TERRA, AQUA, AVHRR, NOVA etc; relationship with actually measured data; application of field models.

Practical

- Measurement and evaluation of radiation components
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Measurement of wind and temperature profiles near the ground

Suggested Readings

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Burman R & Pochop LO. 1994. *Evaporation, Evapotrnspiration and Climatic Data*. Elsvier.
Chang JH. 1968. *Climate and Agriculture*. Aidine Publ.
Evans LT. 1963. *Environmental Control and Plant Growth*. Academic Press.
Gracc J.1983. *Plant Atmospheric Relationships: Outline studies in Ecology*. Chapman & Hall.
Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture.* The Haworth Press.
Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.
Ram Niwas, Diwan Singh & Rao VUM. 2000. *Pratical Manual on Evapotranspiration*. Dept. of Agril. Meteorology, CCS HAU Hisar.
Rose CW. 1966. *Agricultural Physics*. Pugaman.
Rosenberg NJ. 1974. *Microclimate – The Biological Environment*. John Wiley & Sons.

AP 606 CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT 2+1

Objective

To educate students about concept, causes and consequences of global warming on agriculture and food security, and mitigation strategies.

Theory

UNIT I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; non-hydro aerosols, radiation budget, carbon group etc.

UNIT II

Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services.

UNIT III

Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

UNIT IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

UNIT V

Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no-ground cover periods etc.

Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture

Suggested Readings

Anonymous. *Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ.

Anonymous. *IPCC Assessment Reports on Climate Change (2001, 2007)*. WMO, UNEP Publ.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

Jepma CJ & Munasinghe M. 1998. *Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.

Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses.* Cambridge Univ. Press.

Pretty J & Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.

Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.

Salinger J, Sivkumar MVK & Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.

Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

AP 607 WATERSHED MANAGEMENT 1+0

Objective

To teach students about the significance, concept and operational details for development and management of watersheds.

Theory

UNIT I

Concept, objectives and classification of watersheds; components of watershed development and management; collection of hydrological data for developing watersheds, preparation of watershed management plan, unit and codification of watersheds.

UNIT II

Water harvesting: concept, different forms of water harvesting- rainwater harvesting, roof-top water harvesting, water harvesting from other sources, water-harvesting efficiency; rainfall characteristics, rainfall gauging; measurement and estimation of runoff; recycling harvested water for agricultural purposes.

UNIT III

Introduction to success stories; causes of failure of watershed development plans; desertification and its control; watershed modeling.

Suggested Readings

Dhruva Narayan VV, Sastry G & Pathak US. 1990. *Watershed Management*. ICAR.

Mohsin MA 1980. *Watershed Management*. BAU Publ.

Seshagiri Rao KV. 1995. *Watershed – Comprehensive Development*. BS. Publ.

Supporting Courses

AP 511 MATHEMATICS IN AGRICULTURE 2+0

Functions; limits; continuity; linear and non-linear equations; polynomials; infinite series and Taylor series; vectors; matrices and determinants; inversion of matrices; Eigen values and Eigen vectors; orthogonality; least square problems; differentiation; integration; areas; applications; solutions to differential and integral equations; systems of coordinates; Cartesian, Cylindrical, Spherical and Polar coordinates; three dimensional geometry; relative motion of frame of reference; probability, probability distribution and applications; curve fitting; regression and correlation, linear and non-linear; geo-statistics; averaging and scaling methods; Fourier analysis; numerical approximations; numerical analysis; finite element method; Monte Carlo analysis; stochastic methods; iterative and optimal techniques

Suggested Readings: Any book of Mathematics

AP 512 BASIC CONCEPTS OF PHYSICS 2+1

Linear, circular, relative motions; Conservation of mass, energy and momentum; Forces in nature, range of their operation, action at a distance; Gravitational field potential; Elasticity, stress-strain relations, moduli of elasticity; Hooke's law, molecular and structural basis of strengths of materials; Hydrostatic pressure; Surface Tension, capillary rise, contact angle; Hydrodynamics – laminar and streamline flow, Poiseuille's equation; Stoke's law; Thermometry, measurement of heat, specific heat; Transfer of heat-conduction, convection and radiation; Change of phase, equation of state, vapour pressure and relative humidity; Laws of thermodynamics, free energy, chemical potential; Kinetic theory of gases; Brownian motion, mean free path; Simple harmonic motion, concepts of phase, phase difference, interference and reflection of sound waves, ultrasonics, applications; Wave theory of light; Reflection, refraction, diffraction, polarization, interference and scattering of light waves; Electromagnetic theory of light; Geometrical optics, aberrations; Resolving power, principles of optical instruments; Illuminated and luminous objects and light sources; Luminescence, incandescence, fluorescence, auto-fluorescence, phosphorescence, bio-luminiscence; Qualitative and quantitative measurement of light, colour, optical spectrometery; Electric charges, potential, field, intensity and strength of electric field, current, Coulomb's law; Dielectrics, capacitance, electrostatic units; Resistance, resistivity, Ohm's law, steady currents in conductors, insulators and semi conductors; Magnetic materials, induced magnetism, electromagnetism, measurement of magnetic field, geomagnetism, effects of the earth's magnetic field on life; Electromagnetic inductions and applications, electromagnetic units

Suggested Readings: Any book of Basic Physics

AGRICULTURAL PHYSICS

List of Journals

- Advances in Agronomy
- Agricultural Water Management
- Agronomy Journal
- Annals of Arid Zone
- Atmospheric Research
- Australian Journal of Agricultural Research
- Australian Journal of Soil Research
- Canadian Journal of Remote Sensing
- Clays and Clay minerals
- Climate Dynamics
- Climate Research
- Climatic Change
- Crop Science
- Ecological Modelling
- Environmental Monitoring and Assessment
- European Journal of Soil Science
- Geoderma
- GIS India
- Hydrology Journal
- Indian Journal of Environmental Protection
- International Journal of Climatology
- International Journal of Remote Sensing
- Irrigation Science
- Italian Journal of Agrometeorology
- International Journal of Remote Sensing
- Journal of Agricultural Meteorology
- Journal of Agricultural Physics
- Journal of Agricultural Sciences
- Journal of Agrometeorology
- Journal of Applied Hydrology
- Journal of Applied Meteorology and Climatology
- Journal of Earth Systems Science
- Journal of Hydrometeorology
- Journal of Photogrammetry and Remote Sensing
- Journal of Plant Nutrition and Soil Science
- Journal of the Indian Society of Remote Sensing
- Journal of the Indian Society of Soil Science
- Journal of Water Management
- Journal of Weather Modification Association
- Plant and Soil
- Pollution Research
- Remote Sensing of Environment
- Soil and Tillage Research
- Soil Biology and Biochemistry

- Soil Science
- Soil Science Society of America Journal
- Soil Use and Management
- Water Resources Research
- Weather and Forecasting

Suggested Broad Topics for Master's and Doctoral Research

- Carbon management in soils and its impact on soil health
- Crop-weather interaction studies - field investigations and modeling
- Crop-weather-pest interaction studies
- Degradation and restoration of soil as a natural resource
- Development of soil health assessment criteria/indices, especially of soil physical health, and crop impact analysis
- Evapotranspiration studies using different approaches
- Extreme weather events, their impact on agriculture and their alleviation
- Impact of current agricultural practices and agrochemicals on soil quality/biodiversity
- Management of problem soils
- Microclimatic studies in crops and control climate
- Modeling solute (salt, fertilizer, pesticides) transport in soil
- Simulation models for growth and production of different crops
- Tillage and crop residue management in crop production
- Use and impact of poor quality waters in agriculture
- Use of remote sensing and GIS as diagnostic tool for natural resource management, agro-ecological zoning and crop environment characterization
- Utilization of urban and industrial wastes/effluents in agriculture
- Validation of various existing crop simulation models to determine the production potentials in different regions of the state for major crops
- Water management strategies in different cropping systems
- Weather modification studies
- Weather-based agroadvisories, impact assessment and related issues

AGRONOMY

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
AGRON 501*	MODERN CONCEPTS IN CROP PRODUCTION	3+0
AGRON 502*	PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT	2+1
AGRON 503*	PRINCIPLES AND PRACTICES OF WEED MANAGEMENT	2+1
AGRON 504*	PRINCIPLES AND PRACTICES OF WATER MANAGEMENT	2+1
AGRON 505	AGROMETEOROLOGY AND CROP WEATHER FORECASTING	2+1
AGRON 506	AGRONOMY OF MAJOR CEREALS AND PULSES	2+1
AGRON 507	AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS	2+1
AGRON 508	AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED CROPS	2+1
AGRON 509	AGRONOMY OF FODDER AND FORAGE CROPS	2+1
AGRON 510	AGROSTOLOGY AND AGROFORESTRY	2+1
AGRON 511	CROPPING SYSTEMS	2+0
AGRON 512	DRYLAND FARMING	2+1
AGRON 513	PRINCIPLES AND PRACTICES OF ORGANIC FARMING	2+1
AGRON 591	MASTER'S SEMINAR	1+0
AGRON 599	MASTER'S RESEARCH	20
AGRON 601	CURRENT TRENDS IN AGRONOMY	3+0
AGRON 602	CROP ECOLOGY	2+0
AGRON 603	CROP PRODUCTION AND SYSTEM MODELING	2+1
AGRON 604	ADVANCES IN CROP GROWTH AND PRODUCTIVITY	2+1
AGRON 605	IRRIGATION MANAGEMENT	2+1
AGRON 606	ADVANCES IN WEED MANAGEMENT	2+0
AGRON 607	INTEGRATED FARMING SYSTEMS	2+0
AGRON 608	SOIL CONSERVATION AND WATERSHED MANAGEMENT	2+1
AGRON 609	STRESS CROP PRODUCTION	2+1
AGRON 691	DOCTORAL SEMINAR I	1+0
AGRON 692	DOCTORAL SEMINAR II	1+0
AGRON 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme

AGRONOMY
Course Contents

AGRON 501 MODERN CONCEPTS IN CROP PRODUCTION 3+0

Objective

To teach the basic concepts of soil management and crop production.

Theory

UNIT I

Crop growth analysis in relation to environment; gro-ecological zones of India.

UNIT II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

UNIT III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

UNIT IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress.

UNIT V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.

Suggested Readings

Balasubramaniyan P & Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.

Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.

Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.

Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.

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

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

AGRON 502 SOIL FERTILITY AND NUTRIENT MANAGEMENT 2+1

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

UNIT I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

UNIT II

Criteria of essentiality of nutrients; Essential plant nutrients - their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

UNIT III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

UNIT IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.

UNIT V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermin-compost and residue wastes in crops.

Practical

- Determination of soil pH, ECe, organic C, total N, available N, P, K and S in soils
- Determination of total N, P, K and S in plants
- Interpretation of interaction effects and computation of economic and yield optima

Suggested Readings

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

Fageria NK, Baligar VC & Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.

Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Yawalkar KS, Agrawal JP & Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

AGRON 503 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT 2+1

Objective

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

UNIT I

Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification; weed indices.

UNIT II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

UNIT III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation.

UNIT IV

Weed management in major crops and cropping systems; parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control.

UNIT V

Integrated weed management; cost : benefit analysis of weed management.

Practical

- Identification of important weeds of different crops
- Preparation of a weed herbarium
- Weed survey in crops and cropping systems
- Crop-weed competition studies
- Preparation of spray solutions of herbicides for high and low-volume sprayers
- Use of various types of spray pumps and nozzles and calculation of swath width
- Economics of weed control
- Herbicide resistance analysis in plant and soil
- Bioassay of herbicide resistance
- Calculation of herbicidal requirement

Suggested Readings

Aldrich RJ & Kramer RJ. 1997. *Principles in Weed Management*. Panima Publ.

Ashton FM & Crafts AS. 1981. *Mode of Action of Herbicides*. 2nd Ed. Wiley Inter-Science.

Gupta OP. 2007. *Weed Management – Principles and Practices.* Agrobios.

Mandal RC. 1990. *Weed, Weedicides and Weed Control - Principles and Practices*. Agro-Botanical Publ.

Rao VS. 2000. *Principles of Weed Science*. Oxford & IBH.

Subramanian S, Ali AM & Kumar RJ. 1997. *All About Weed Control*. Kalyani.

Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic Press.

AGRON 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 2+1

Objective

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

Theory

UNIT I

Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

UNIT II

Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition.

UNIT III

Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and poly-houses.

UNIT IV

Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency.

UNIT V

Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

Practical

- Measurement of soil water potential by using tensiometer, and pressure plate and membrane apparatus
- Soil-moisture characteristics curves
- Water flow measurements using different devices
- Determination of irrigation requirements
- Calculation of irrigation efficiency
- Determination of infiltration rate
- Determination of saturated/unsaturated hydraulic conductivity

Suggested Readings

Lenka D. 1999. *Irrigation and Drainage*. Kalyani

Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.

Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

Prihar SS & Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

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

AGRON 505 AGROMETEOROLOGY AND CROP WEATHER FORECASTING 2+1

Objective

To impart knowledge about agro-meteorology and crop weather forecasting to meet the challenges of aberrant weather conditions.

Theory

UNIT I

Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind.

UNIT II

Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature.

UNIT III

Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration.

UNIT IV

Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation.

UNIT V

Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

Practical

- Visit to agro-meteorological observatory and to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure
- Measurement of solar radiation outside and within plant canopy
- Measurement/estimation of evapo-transpiration by various methods
- Measurement/estimation of soil water balance
- Rainfall variability analysis
- Determination of heat-unit requirement for different crops
- Measurement of crop canopy temperature
- Measurement of soil temperatures at different depths
- Remote sensing and familiarization with agro-advisory service bulletins
- Study of synoptic charts and weather reports, working principle of automatic weather station
- Visit to solar observatory

Suggested Readings

Chang Jan Hu 1968. *Climate and Agriculture on Ecological Survey*. Aldine Publ.

Critchfield HJ.1995. *General Climatology.* Prentice Hall of India.

Das PK.1968. *The Monsoons*. National Book Trust Publ.

Lal DS.1998. *Climatology*. Sharda Pustak Bhawan.

Lenka D.1998. *Climate, Weather and Crops in India*. Kalyani.

Mavi H.S.1994. *Introduction to Agro-meteorology*. Oxford & IBH.

Mavi HS & Tupper GJ. 2004. *Agrometeorology: Principles and Application of Climate Studies in Agriculture.* Haworth Press.
Menon PA.1991. *Our Weather.* National Book Trust Publ.
Sahu DD. *Agrometeorology and Remote Sensing: Principles and Practices.* Agrobios.
Variraju R & Krishnamurty 1995. *Practical Manual on Agricultural Meteorology*. Kalyani.
Varshneya MC & Balakrishana Pillai P. 2003. *Textbook of Agricultural Meteorology*. ICAR.

AGRON 506 AGRONOMY OF MAJOR CEREALS AND PULSES 2+1

Objective

To teach the crop husbandry of cereals and pulse crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of

UNIT I

Rabi cereals.

UNIT II

Kharif cereals.

UNIT III

Rabi pulses.

UNIT IV

Kharif pulses.

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CER, CGR, RGR, NAR, LAD), aggressiveness, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems of different crops
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
Hunsigi G & Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.

Jeswani LM & Baldev B. 1997. *Advances in Pulse Production Technology*. ICAR.
Khare D & Bhale MS. 2000. *Seed Technology*. Scientific Publ.
Kumar Ranjeet & Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
Pal M, Deka J & Rai RK. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
Prasad, Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.
Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
Singh, SS. 1998. *Crop Management*. Kalyani.
Yadav DS. 1992. *Pulse Crops*. Kalyani.

AGRON 507 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS 2+1

Objective

To teach the crop husbandry of oilseed, fiber and sugar crops.

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and processing of the produce for maximum production of :

UNIT I

Rabi oilseeds – Rapeseed and mustard, linseed, etc.

UNIT II

Kharif oilseeds - Groundnut, sesame, castor, sunflower, soybean etc.

UNIT III

Fiber crops - Cotton, jute, sunhemp etc.

UNIT IV

Sugar crops – Sugar-beet and sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (LER, CGR, RGR, NAR, LAD) aggressivity, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops

- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

Das PC. 1997. *Oilseed Crops of India*. Kalyani.

Lakshmikantam N. 1983. *Technology in Sugarcane Growing*. 2nd Ed. Oxford & IBH.

Prasad, Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.

Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.

Singh SS. 1998. *Crop Management*. Kalyani.

AGRON 508 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS 2+1

Objective

To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices and processing.

Theory

UNIT I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and uses.

UNIT II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, *Nux vomica*, Rosadle etc).

UNIT III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium etc.).

UNIT IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Practical

- Identification of crops based on morphological and seed characteristics
- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants

Suggested Readings

Chadha KL & Gupta R. 1995. *Advances in Horticulture*. Vol. II. *Medicinal and Aromatic Plants*. Malhotra Publ.

Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

Handa SS. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Hussain A. 1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.

Hussain A. 1993. *Medicinal Plants and their Cultivation.* CIMAP, Lucknow.

ICAR 2006. *Hand Book of Agriculture.* ICAR, New Delhi.

Kumar N, Khader Md. Abdul, Rangaswami JBM & Irulappan 1997. I*ntroduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.

Prajapati ND, Purohit SS, Sharma AK & Kumar T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book*. Agrobios.

Sharma R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

AGRON 509 AGRONOMY OF FODDER AND FORAGE CROPS 2+1

Objective

To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory

UNIT I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne etc.

UNIT II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses-lime, napier grass, *Panicum, Lasiuras, Cenchrus* etc.

UNIT III

Year-round fodder production and management, preservation and utilization of forage and pasture crops.

UNIT IV

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.

UNIT V

Economics of forage cultivation uses and seed production techniques.

Practical

- Practical raining of farm operations in raising fodder crops;
- Canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation

Suggested Readings

Chatterjee BN. 1989. *Forage Crop Production - Principles and Practices*. Oxford & IBH.

Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.

Narayanan TR & Dabadghao PM. 1972. *Forage Crops of India*. ICAR.

Singh P & Srivastava AK. 1990. *Forage Production Technology*. IGFRI, Jhansi.

Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
Tejwani KG. 1994. *Agroforestry in India*. Oxford & IBH.

AGRON 510 AGROSTOLOGY AND AGRO-FORESTRY 2+1

Objective

To teach crop husbandry of different forage, fodder and agroforestry crops/trees along with their processing.

Theory

UNIT I

Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

UNIT II

Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

UNIT III

Agroforestry: definition and importance; agroforestory systems, agri-silviculture, silvipasture, agrisilvipasture, agrihorticulture, aqua-silviculture, alley cropping and energy plantation.

UNIT IV

Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

Suggested Readings

Chatterjee BN & Das PK. 1989. *Forage Crop Production. Principles and Practices.* Oxford & IBH.

Dabadghao PM & Shankaranarayan KA. 1973. *The Grass Cover in India*. ICAR.
Dwivedi AP. 1992. *Agroforestry- Principles and Practices.* Oxford & IBH.
Indian Society of Agronomy. 1989. *Agroforestry System in India. Research and Development,* New Delhi.
Narayan TR & Dabadghao PM. 1972. *Forage Crop of India*. ICAR, New Delhi.
Pathak PS & Roy MM. 1994. *Agroforestry System for Degraded Lands*. Oxford & IBH.
Sen NL, Dadheech RC, Dashora LK & Rawat TS. 2004. *Manual of Agroforestry and Social Forestry.* Agrotech Publ.
Shah SA.1988. *Forestry for People*. ICAR.
Singh Panjab, Pathak PS & Roy MM.1994. *Agroforestry System for Sustainable Use*. Oxford & IBH.
Singh SP. 1994. *Handbook of Agroforestry.* Agrotech Publ.
Solanki KR. 2000. *Multipurpose Tree Species: Research, Retrospect and Prospects*. Agrobios.
Tejwani KG.1994. *Agroforestry in India.* Oxford & IBH.

AGRON 511 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE 2+0

Objective

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

Theory

UNIT I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

UNIT II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

UNIT III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

UNIT IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system.

UNIT V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Suggested Readings

Palaniappan SP & Sivaraman K. 1996. *Cropping Systems in the Tropics; Principles and Management.* New Age.
Panda SC. 2003. *Cropping and Farming Systems*. Agrobios.
Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Sankaran S & Mudaliar TVS. 1997. *Principles of Agronomy.* The Bangalore Printing & Publ. Co.
Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

AGRON 512 DRYLAND FARMING AND WATERSHED MANAGEMENT 2+1

Objective

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

Theory

UNIT I

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

UNIT II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

UNIT III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

UNIT IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use.

UNIT V

Concept of watershed resource management, problems, approach and components.

Practical

- Seed treatment, seed germination and crop establishment in relation to soil moisture contents
- Moisture stress effects and recovery behaviour of important crops
- Estimation of moisture index and aridity index
- Spray of anti-transpirants and their effect on crops
- Collection and interpretation of data for water balance equations
- Water use efficiency
- Preparation of crop plans for different drought conditions
- Study of field experiments relevant to dryland farming
- Visit to dryland research stations and watershed projects

Suggested Readings

Das NR. 2007. *Tillage and Crop Production*. Scientific Publishers.
Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.

Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.

Gupta US. (Ed.). 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH.

Katyal JC & Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.

Rao SC & Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publishers.

Singh P & Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publishing Company.

Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.

Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.

Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publishers.

Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

AGRON 513 PRINCIPLES AND PRACTICES OF ORGANIC FARMING 2+1

Objective

To study the principles and practices of organic farming for sustainable crop production.

Theory

UNIT I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use, minimum tillage; shelter zones, hedges, pasture management, agro-forestry.

UNIT II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers.

UNIT III

Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

UNIT IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides.

UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Aerobic and anaerobic methods of making compost
- Making of vermicompost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts

- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Suggested Readings

Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.

Lampin N. 1990. *Organic Farming*. Press Books, lpswitch, UK.

Palaniappan SP & Anandurai K. 1999. *Organic Farming – Theory and Practice.* Scientific Publ.

Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, Parisaraprajna Parishtana, Bangalore.

Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.

Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.

Singh SP. (Ed.) 1994. *Technology for Production of Natural Enemies.* PDBC, Bangalore.

Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.

Trivedi RN.1993. *A Text Book of Environmental Sciences*, Anmol Publ.

Veeresh GK, Shivashankar K & Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture.* Association for Promotion of Organic Farming, Bangalore.

WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*. WHO.

Woolmer PL & Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

AGRON 601 CURRENT TRENDS IN AGRONOMY 3+0

Objective

To acquaint the students about recent advances in agricultural production.

Theory

UNIT I

Agro-physiological basis of variation in yield, recent advances in soil-plant-water relationship.

UNIT II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures.

UNIT III

Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

UNIT IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc.

UNIT V

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

Suggested Readings

Agarwal RL. 1995. *Seed Technology*. Oxford & IBH.

Dahiya BS & Rai KN. 1997. *Seed Technology*. Kalyani.

Govardhan V. 2000. *Remote Sensing and Water Management in Command Areas: Agroecological Prospectives*. IBDC.

ICAR. 2006. *Hand Book of Agriculture*. ICAR.

Narasaiah ML. 2004. *World Trade Organization and Agriculture*. Sonali Publ.

Palaniappan SP & Annadurai K. 2006. *Organic Farming - Theory and Practice*. Scientific Publ.

Sen S & Ghosh N. 1999. *Seed Science and Technology*. Kalyani.

Tarafdar JC, Tripathi KP & Mahesh Kumar 2007. *Organic Agriculture*. Scientific Publ.

AGRON 602 CROP ECOLOGY 2+0

Objective

To acquaint the students about the agricultural systems, agro-ecological regions, and adaptation of crops to different agro-climatic conditions.

Theory

UNIT I

Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply.

UNIT II

Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.

UNIT III

Physiological response of crop plants to light, temperature, CO_2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.

UNIT IV

Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production.

UNIT V

Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop selection and management.

Suggested Readings

Ambasht RS. 1986. *A Text Book of Plant Ecology*. 9th Ed. Students' Friends & Co.

Chadha KL & Swaminathan MS. 2006. *Environment and Agriculture*. Malhotra Publ. House.
Dwivedi P, Dwivedi SK & Kalita MC. 2007. *Biodiversity and Environmental Biotechnology.* Scientific Publ.
Hemantarajan A. 2007. *Environmental Physiology*. Scientific Publ.
Kumar HD. 1992. *Modern Concepts of Ecology*. 7th Ed. Vikas.Publ.
Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.
Misra KC. 1989. *Manual of Plant Ecology*. 3rd Ed. Oxford & IBH.
Pandey SN & Sinha BK. 1995. *Plant Physiology*. Vikas Publ.
Sharma PD. 1998. *Ecology and Environment*. Rastogi Publ.
Singh J & Dhillon SS. 1984. *Agricultural Geography.* Tata McGraw Hill.
Taiz L & Zeiger E. 1992. *Plant Physiology*. Benjamin/Cummings Publ.

AGRON 603 CROP PRODUCTION AND SYSTEM MODELING 2+1

Objective

To familiarize the students about systems approach and to simulate yields and growth of several crops under varied soil and weather conditions with different management practices and their optimization.

Theory

UNIT I

Systems classification; flow charts, modeling techniques and methods of integration - state, rates and driving variables, feedbacks and relational diagrams.

UNIT II

Elementary models for crop growth based on basic methods of classical growth analysis.

UNIT III

Crop modeling methods for crop-weather interaction, climate change and variability components.

UNIT IV

Potential production: leaf and canopy CO_2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

UNIT V

Production by moisture availability, potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

Practical

- Simulation of elementary models for crop growth
- Simulation of potential production
- Simulation with limitations of water and nutrient management options
- Sensitivity analysis using different climatic years and crop management practices

Suggested Readings

Gordan G. 1992. *System Simulation*. 2nd Ed. Prentice Hall.
Kropff MJ & Vann Laar HH. (Ed.). 1993. *Modelling Crop Weed Interactions*. ISBN.
Mathews RB, Kropff MJ, Bachelet D & Vaan Laar HH. (Eds.). 1993. *Modelling the Impact of Climate Change on Rice Production in Asia.* CABI.

Penning de Vries FWT & Van Laar HH. (Eds.). 1982. *Simulation of Plant Growth and Crop Production*. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.

Ritchie JT & Hanks J. 1991. *Modelling Plant and Soil Systems*. American Society of Agronomy, Madison.

Zeigler BP. 1976. *Theory of Modeling and Simulation*. John Wiley & Sons.

AGRON 604 ADVANCES IN CROP GROWTH AND PRODUCTIVITY 2+1

Objective

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory

UNIT I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

UNIT II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

UNIT III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

UNIT IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
- Senescence and abscission indices

- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

Suggested Readings

Chopra VL & Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford and IBH.

Delvin RM & Vitham FH. 1986. *Plant Physiology*. CBS Publ.

Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.

Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.

Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.

Gupta US. 1988. *Progress in Crop Physiology*. Oxford and IBH.

Kramer PJ & Boyer JS. 1995. *Water Relations of Plant and Soils.* Academic Press.

Mukherjee S & Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.

Narwal SS, Politycka B & Goswami CL. 2007. *Plant Physiology: Research Methods.* Scientific Publishers.

AGRON 605 IRRIGATION MANAGEMENT 2+1

Objective

To teach students about optimization of irrigation in different crops under variable agroclimatic conditions.

Theory

UNIT I

Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

UNIT II

Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

UNIT III

Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

UNIT IV

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

UNIT V

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

UNIT VI

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles
- Moisture extraction pattern of crops
- Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity
- Crop planning at the farm and project level
- Agronomic evaluation of irrigation projects, case studies

Suggested Readings

FAO. 1984. *Irrigation Practice and Water Management.* Oxford & IBH.

Michael AM. 1978. *Irrigation: Theory and Practice*.Vikas Publ.

Mishra RR & Ahmad M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.

Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.

AGRON 606 ADVANCES IN WEED MANAGEMENT 2+0

Objective

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

UNIT I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects.

UNIT II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

UNIT III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.

UNIT IV

Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.

UNIT V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

UNIT VI

Relationship of herbicides with tillage, fertilizer and irrigation; bio-herbicides, allelochemical herbicide bioassays.

Suggested Readings

Aldrich RJ & Kramer R.J. 1997. *Principles in Weed Management*. Panama Publ.

Ashton FM & Crafts AS. 1981. *Mode of Action of Herbicides*. 2nd Ed. Wiley-Inter Science.

Gupta OP. 2000. *Weed Management – Principles and Practices*. Agrobios.

Mandal RC. 1990. *Weed, Weedicides and Weed Control - Principles and Practices*. Agro-Botanical Publ.

Rao VS. 2007. *Principles of Weed Science*. Oxford & IBH.

Ross MA & Carola Lembi A. 1999. *Applied Weed Science.* 2nd Ed. Prentice Hall.

Subramanian SAM & Kumar R.J. 1997. *All About Weed Control*. Kalyani.

Zimdahl RL. 1999. *Fundamentals of Weed Science*. 2nd Ed. Academic Press.

AGRON 607 INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE 2+0

Objective

To apprise about different enterprises suitable for different agroclimatic conditions for sustainable agriculture.

Theory

UNIT I

Farming systems: definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II

Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III

Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.

UNIT IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.

UNIT V

New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Suggested Readings

Ananthakrishnan TN. (Ed.) 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Balasubramanian P & Palaniappan SP 2006. *Principles and Practices of Agronomy*. Agrobios.

Joshi M & Parbhakarasetty TK. 2005. *Sustainability through Organic Farming*. Kalyani.

Lampin N. 1990. *Organic Farming*. Farming Press Books.

Palaniappan SP & Anandurai K. 1999. *Organic Farming - Theory and Practice*. Scientific Publ.

Panda SC. 2004. *Cropping systems and Farming Systems*. Agribios.
Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
Sharma AK. 2001. *A Hand Book of Organic Farming*. Agrobios.
Singh SP. (Ed) 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.
Trivedi RN. 1993. *A Text Book of Environmental Sciences*. Anmol Publ.
Veeresh GK, Shivashankar K & Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture*. Association for Promotion of Organic Farming, Bangalore.
Venkata Rao BV. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*. Publ. 3. Parisaraprajna Parishtana, Bangalore.

AGRON 608 SOIL CONSERVATION AND WATERSHED MANAGEMENT 2+1

Objective

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Theory

UNIT I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

UNIT II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III

Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

UNIT IV

Land use capability classification, alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-ethnic aspects, its layout.

UNIT V

Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Practical

- Study of different types of erosion
- Field studies of different soil conservation measures
- Run-off and soil loss measurements
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to a soil conservation research centre, demonstration and training centre

Suggested Readings

Arakeri HR & Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.

Dhruvanarayana VV. 1993. *Soil and Water Conservation Research in India*. ICAR.

FAO. 2004. *Soil and Water Conservation in Semi-Arid Areas*. *Soils Bull.,* Paper 57.

Frederick RT, Hobbs J, Arthur D & Roy L. 1999. *Soil and Water Conservation: Productivity and Environment Protection.* 3rd Ed. Prentice Hall.

Gurmel Singh, Venkataraman CG, Sastry B & Joshi P. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Murthy VVN. 1995. *Land and Water Management Engineering*. Kalyani.

Tripathi RP & Singh HP. 1993. *Soil Erosion and Conservation*. Wiley Eastern.

Yellamanda Reddy T & Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

AGRON 609 STRESS CROP PRODUCTION 2+1

Objective

To study various types of stresses in crop production and strategies to overcome them.

Theory

UNIT I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

UNIT II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature tress through, soil and crop manipulations.

UNIT II

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT III

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

UNIT IV

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

UNIT V

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.

UNIT VI

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

UNIT VII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions

Suggested Readings

Baker FWG.1989. *Drought Resistance in Cereals*. Oxon, UK.

Gupta U.S. (Ed.). 1988. *Physiological Aspects of Dryland Farming.* Oxford & IBH.

Kramer PJ.1983. *Water Relations of Plants*. Academic Press.

Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.

Mavi HS.1978. *Introduction to Agro-meteorology*. Oxford & IBH.

Michael AM & Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.

Nilsen ET & Orcut DM. 1996. *Physiology of Plants under Stress - Abiotic Factors*. John Wiley & Sons.

Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.

Singh KN & Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.

Somani LL & Totawat KL. 1992. *Management of Salt-affected Soils and Waters.* Agrotech Publ.

Virmani SM, Katyal JC, Eswaran H & Abrol IP.1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

AGRONOMY
List of Journals

- Advances in Agronomy
- Agriculture, Ecosystems and Environment
- Agricultural Systems
- Agricultural Water Management
- Agronomy Journal
- Annual Review of Plant Physiology
- Applied Ecology and Environment Research
- Australian Journal of Agricultural Research
- Australian Journal of Experimental Agriculture
- Crop Protection
- Environment and Ecology
- European Journal of Agronomy
- Fertilizer Research
- Field Crops Research
- Indian Journal of Agricultural Sciences
- Indian Journal of Agronomy
- Indian Journal of Ecology
- Indian Journal of Weed Science
- Irrigation Science
- Japanese Journal of Crop Science
- Journal of Agronomy
- Journal of Applied Ecology
- Journal of Experimental Botany
- Journal of Farming Systems Research
- Journal of Range Management
- Journal of Agricultural Science Cambridge
- Journal of Sustainable Agriculture
- Netherlands Journal of Agricultural Sciences
- Nutrient Cycling in Agroecosystems
- Pesticide Biochemistry and Physiology
- Plant and Soil
- Plant Production Science
- Soil and Tillage Research
- Swedish Journal of Agricultural Research
- Tropical Agriculture
- Weed Research

Suggested Broad Topics for Master's and Doctoral Research

- Crop diversification under different agricultural situations
- Development of farming systems for marginal, small and other farmers
- Agricultural information at door step/click of mouse
- Farm-specific nutrient management
- Weed management in different cropping/farming systems
- Nutrient studies in different cropping/farming systems
- Biodiversity of farming systems for conservation
- Organic farming systems for different regions
- Modeling for different crop situations
- Conservation agriculture for yield sustainability
- Role of edaphic factors on weeds proliferation and management
- Implications of global warming on weed growth and herbicide behaviour
- Ecological implications of using thresholds for weed management
- Effect of cultivation practices and herbicides on weed flora shift
- GM crops and weed management strategies
- Weed management under reduced moisture regime in major summer/*kharif* crops
- Avoidance of herbicide resistance using IWM

SOIL SCIENCE

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
SOILS 501*	SOIL PHYSICS	2+1
SOILS 502*	SOIL FERTILITY AND FERTILIZER USE	3+1
SOILS 503*	SOIL CHEMISTRY	2+1
SOILS 504*	SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY	2+1
SOILS 505	SOIL EROSION AND CONSERVATION	2+1
SOILS 506*	SOIL BIOLOGY AND BIOCHEMISTRY	2+1
SOILS 507	GEOMORPHOLOGY AND GEOCHEMISTRY	2+0
SOILS 508	RADIOISOTOPES IN SOIL AND PLANT STUDIES	1+1
SOILS 509	SOIL,WATER AND AIR POLLUTION	2+1
SOILS 510	REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES	2+1
SOILS 511	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	0+2
SOILS 512	SYSTEM APPROACHES IN SOIL AND CROP STUDIES	2+1
SOILS 513	MANAGEMENT OF PROBLEMATIC SOILS AND WATERS	2+1
SOILS 514	FERTILIZER TECHNOLOGY	1+0
SOILS 515	LAND DEGRADATION AND RESTORATION	1+0
SOILS 591	MASTER'S SEMINAR	1+0
SOILS 599	MASTER'S RESEARCH	20
SOILS 601	ADVANCES IN SOIL PHYSICS	2+0
SOILS 602	ADVANCES IN SOIL FERTILITY	2+0
SOILS 603	PHYSICAL CHEMISTRY OF SOILS	2+0
SOILS 604	SOIL GENESIS AND MICROPEDOLOGY	2+0
SOILS 605	BIOCHEMISTRY OF SOIL ORGANIC MATTER	2+0
SOILS 606	LAND USE PLANNING AND WATERSHED MANAGEMENT	2+0
SOILS 691	DOCTORAL SEMINAR I	1+0
SOILS 692	DOCTORAL SEMINAR II	1+0
SOILS 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme

SOIL SCIENCE

Course Contents

SOILS 501 SOIL PHYSICS 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 consistence; 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 crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT VII

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

UNIT 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

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.

Ghildyal BP & Tripathi RP. 2001. *Soil Physics*. New Age International.

Hanks JR & Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.

Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.

Hillel D. 1998. *Environmental Soil Physic*s. Academic Press.

Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.

Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.

Kohnke H. 1968. *Soil Physics*. McGraw Hill.

Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Saha AK. 2004. *Text Book of Soil Physics*. Kalyani.

SOILS 502 SOIL FERTILITY AND FERTILIZER USE 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 use efficiency.

UNIT III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.

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
- Analysis of plants for essential elements

Suggested Readings

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

Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality.* 2nd Ed. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers.* 5th Ed. Prentice Hall of India.

Troeh FR & Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

SOILS 503 SOIL CHEMISTRY 2+1

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; soil organic matter - fractionation of soil organic matter and different fractions, 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, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; 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, chemistry of acid soils; sub-soil acidity.

UNIT VII

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

UNIT VIII

Chemistry and electrochemistry of submerged soils.

Practical

- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, E_h by the use of E_h-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
- (E_4/E_6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Δ (E_4/E_6) 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 $BaCl_2$-TEA method
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford and IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.

Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 504 SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY 2+1

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UNIT I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

UNIT II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils.

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality
- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

Suggested Readings

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

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

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

Grim RE. 1968. *Clay Mineralogy*. McGraw Hill.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Sehgal J. 2002. *Introductory Pedology: Concepts and Applications*. New Delhi

Sehgal J. 2002. *Pedology - Concepts and Applications*. Kalyani.

USDA. 1999. *Soil Taxonomy*. Hand Book No**.** 436. 2nd Ed. USDA NRCS, Washington.

Wade FA & Mattox RB. 1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.

Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*. Elsevier.

Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy*. I. *Concept and Interaction*. Elsevier.

SOILS 505 SOIL EROSION AND CONSERVATION 2+1

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 EI_{30} 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; socio-economic 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 - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI_{30}) using rain gauge data
- Visits to a watersheds

Suggested Readings

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

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

SOILS 506 SOIL BIOLOGY AND BIOCHEMISTRY 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; un-culturable soil biota.

UNIT II

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

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV

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

UNIT V

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

UNIT VI

Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

- Determination of soil microbial population
- 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, N_2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect

Suggested Readings

Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.

Burges A & Raw F. 1967. *Soil Biology*. Academic Press.

McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.

Metting FB. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.

Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.

Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.

Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill.

Stotzky G & Bollag JM. 1993. *Soil Biochemistry.* Vol. VIII. Marcel Dekker.

Sylvia DN. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.

Wild A. 1993. *Soil and the Environment - An Introduction*. Cambridge Univ. Press.

SOILS 507 GEOMORPHOLOGY AND GEOCHEMISTRY 2+0

Objective

To impart knowledge about the landforms, physiography and morphology of the earth surface, and distribution and weathering elements in the earth crust.

Theory

UNIT I

General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India.

UNIT II

Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape.

UNIT III

Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

Suggested Readings

Brikland PW. 1999. *Soils and Geomorophology*. 3rd Ed. Oxford Univ. Press.

Likens GE & Bormann FH. 1995. *Geochemistry*. 2nd Ed. Springer Verlag.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

SOILS 508 RADIOISOTOPES IN SOIL AND PLANT STUDIES 1+1

Objective

To train students in the use of radioisotopes in soil and plant research

Theory

UNIT I

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter

UNIT II

Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography

UNIT III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

UNIT IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes
- Determination of A, E and L values of soil using ^{32}P/ ^{65}Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of ^{15}N enrichment by mass spectrophotometery/ emission spectrometry

Suggested Readings

Comer CL. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill.

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

Michael FL & Annunziata. 2003. *Handbook of Radioactivity Analysis*. Academic Press.

SOILS 509 SOIL, WATER AND AIR POLLUTION 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 micro-organisms.

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 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

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect.* CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience.

Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.

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

SOILS 510 REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES 2+1

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, microwave radiometers 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

Suggested Readings

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

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

Lillesand TM & Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.

Nielsen DR & Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.

Star J & Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

SOILS 511 ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS **0+2**

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 titration; soil, water and plant sampling techniques, their processing and handling.

UNIT II

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

UNIT III

Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods.

UNIT IV

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

UNIT V

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.

UNIT VI

Determination of lime and gypsum requirement of soil; drawing normalized exchange isotherms; measurement of redox potential.

UNIT VII

Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

Suggested Readings

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

Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.

Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.

Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.

Page AL, Miller RH & Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.

Piper CE. *Soil and Plant Analysis*. Hans Publ.

Singh D, Chhonkar PK & Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.

Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.

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

Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

SOILS 512 SYSTEM APPROACHES IN SOIL AND CROP STUDIES 2+1

Objective

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

Theory

UNIT I

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study.

UNIT II

Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and validation, calibration; representation of continuous systems simulation models - procedural and declarative.

UNIT III

Simulation - meaning and threats; simulation experiment, its design and analysis.

UNIT IV

Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under

different soil, water, nutrient, climatic and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

- Use of flow chart or pseudo-code in the program writing
- Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic)
- Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion

Suggested Readings

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

Hanks J & Ritchie JT. (Eds.). 1991. *Modelling Plant and Soil System. Agronomy***.** Bull. No 31. Soil Sci. Society of America, Madison.

Rajaraman V. 2004. *Computer Programming in Fortran 90 and 95*. PHI.

Tsuji GY, Gerrit H & Philip T. 1998. *Understanding Options for Agricultural Production.* Kluwer.

von Bertalanffy Ludwig 1969. *General Systems Theory: Foundation Development and Application*. Revised Ed. George Braziller Reprint 1998.

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 MC Penning de Vries FWT, 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
- Ecological Modeling – Elsevier at http://www.elsevier.com/locate/ecolmodel

SOILS 513 MANAGEMENT OF PROBLEM SOILS AND WATERS 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, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible**.**

UNIT II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties.

UNIT III

Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

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

Suggested Readings

Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

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

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

SOILS 514 FERTILIZER TECHNOLOGY 1+0

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

UNIT I

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order.

UNIT II

Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents.

UNIT III

Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order.

UNIT IV

New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations.

Suggested Readings

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

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

Kanwar JS. (Ed.). 1976. *Soil Fertility: Theory and Practice*. ICAR.

Olson RA, Army TS, Hanway JJ & Kilmer VJ. 1971. *Fertilizer Technology and Use.* 2nd Ed. Soil Sci. Soc. Am. Madison.

Prasad R & Power JF. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers.* McMillan Publ.

Vogel AI. 1979. *Textbook of Quantitative Inorganic Analysis*. ELBS.

SOILS 515 LAND DEGRADATION AND RESTORATION 1+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment. Bull. Indian Soc. Soil Sci.* 17, New Delhi.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.

Greenland DJ & Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.

Lal R, Blum WEH, Vailentine C & Stewart BA. 1997. *Methods for Assessment of Soil Degradation.* CRC Press.

Sehgal J & Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

SOILS 601 ADVANCES IN SOIL PHYSICS 2+0

Objective

To provide knowledge of modern concepts in soil physics.

Theory

UNIT I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.

UNIT II

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.

UNIT III

Theories of horizontal and vertical infiltration under different boundary conditions.

UNIT IV

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.

UNIT V

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.

UNIT VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in agriculture.

UNIT VII

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.

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.

Hanks and Ascheroft. 1980. *Applied Soil Physics*. Springer Verlag.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Environmental Soil Physi*cs. Academic Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.

Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.

Oswal MC.1994. *Soil Physics*. Oxford & IBH.

SOILS 602 ADVANCES IN SOIL FERTILITY 2+0

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

UNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II

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.

UNIT III

Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI

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.

Suggested Readings

Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.

Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition*. CRC / Taylor & Francis.

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

Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.

Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives*. International Potash Institute, Switzerland.

Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technolo*gy. Scientific Publ.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. *Micronutrients in Agriculture.* 2nd Ed. Soil Science Society of America, Madison.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients.* John Wiley & Sons.

Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers.* 5th Ed. Macmillan Publ.

Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed. Longman.

SOILS 603 PHYSICAL CHEMISTRY OF SOILS 2+0

Objective

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

UNIT I

Colloidal chemistry of inorganic and organic components of soils - their formation, clay organic interaction.

UNIT II

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.

UNIT III

Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction.

UNIT IV

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).

UNIT V

Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford & IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Fried M & Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition.* Academic Press.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.

Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.

van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 604 SOIL GENESIS AND MICROPEDOLOGY 2+0

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

UNIT I

Pedogenic evolution of soils; soil composition and characterization.

UNIT II

Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals.

UNIT III

Assessment of soil profile development by mineralogical and chemical analysis.

UNIT IV

Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Suggested Readings

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

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

SOILS 605 BIOCHEMISTRY OF SOIL ORGANIC MATTER 2+0

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

UNIT I

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools.

UNIT II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

UNIT III

Nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

UNIT IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

UNIT V

Humus - pesticide interactions in soil, mechanisms.

Suggested Readings

Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. Organic *Substances in Soil and Water: Natural Constituents and their*

Influences on Contaminant Behavior. Royal Society of Chemistry, London.
Gieseking JE. 1975. *Soil Components*. Vol. 1. *Organic Components*. Springer-Verlag.
Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A Global Perspective.* CSIRO Publ.
Magdoff F & Weil RR 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.
Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture.* John Wiley & Sons.
Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.
Stevenson FJ. 1994. *Humus Chemistry – Genesis, Composition and Reactions.* John Wiley & Sons.

SOILS 606 LAND USE PLANNING AND WATERSHED MANAGEMENT 2+0

Objective

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

Theory

UNIT I

Concept and techniques of land use planning; factors governing present land use.

UNIT II

Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT III

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

UNIT IV

Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity.

UNIT V

Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.
FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.
Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.
Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8th Ed. USDA & NRCS, Washington, DC.
USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

SOIL SCIENCE

List of Journals

- Advances in Agronomy
- Annals of Arid Zone
- Australian Journal of Agricultural Research
- Australian Journal of Soil Research
- Biology and Fertility of Soils
- Communications in Soil Science and Plant Analysis
- Clays and Clay minerals
- European Journal of Soil Science
- Geoderma
- Indian Journal of Agricultural Sciences
- Journal of Plant Nutrition and Soil Science
- Journal of the Indian Society of Soil Science
- Nutrient Cycling in Agroecosystems
- Plant and Soil
- Soil and Tillage Research
- Soil Biology and Biochemistry
- Soil Science
- Soil Science Society of America Journal
- Soil Use and Management
- Water, Air and Soil Pollution
- Water Resources Research

Suggested Broad Topics for Master's and Doctoral Research

- Degradation and restoration of soil as natural resource
- Biochemistry of processes at the soil-root interface
- Impact of current agricultural practices and agrochemicals on soil quality/biodiversity
- Integrated nutrient management for sustainable agriculture
- Fertilizer use efficiency in different soil conditions/cropping systems
- Use of remote sensing and GIS as diagnostic tool for natural resource management
- Role of biological agents in soil productivity
- Modeling solute (salt, fertilizer, pesticides) transport in soil
- Use of poor quality waters in Agriculture
- Soil testing and crop response
- Site-specific nutrient management and precision agriculture
- Nutrient dynamics in soil-plant system and modeling nutrient uptake
- Tillage and crop residue management in crop production
- Utilization of urban and industrial wastes/effluents in Agriculture
- Management of problematic soils
- Impact of climate change on soil processes
- Micronutrients in soil, plant and human health
- Water management strategies in different cropping systems
- Simulation models for growth and production of different crops
- Varietals response to soil salinity/ sodicity/ nutrients/ pollutants, etc
- Soil and water pollution - monitoring and control
- Genesis, formation and classification of soils
- Soil conservation, preservation and management for sustainable agriculture
- Remediation of polluted and contaminated soils

COMPULSORY NON-CREDIT COURSES

(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-Course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-Course)	DISASTER MANAGEMENT	1+0

Course Contents

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective

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

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc.

To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings - theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction,

review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS 503 (e-Course) **INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE** **1+0**

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material

transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

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

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

PGS 505 (e-Course) **AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES** **1+0**

Objective

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

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K.. 1998. *Rural Development - Principles, Policies and Management.* Sage Publ.

PGS 506 (e-Course) **DISASTER MANAGEMENT** **1+0**

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches,

volcanic eruptions, Heat and cold waves, Climatic change: Global warming, Sea level rise, Ozone depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response: Police and other organizations.

Suggested Readings

Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.