Publication No: ICAR/ED(A)/Pub-9/5-2000

CURRICULA AND SYLLABI FOR
MASTER'S DEGREE PROGRAMS

AGRONOMY
AGRICULTURAL PHYSICS
AGRICULTURAL METEOROLOGY
SOIL SCIENCE AND
AGRICULTURAL CHEMISTRY

EDUCATION DIVISION
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN, PUSA, NEW DELHI 110012

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PREFACE

The agriculture scenario in the post Green Revolution era has changed Indian agriculture from the subsistence farming to a commercial enterprise. Signing of World Trade agreement by India has exposed Indian farmers to the global competition. This demands rapid modernization of Indian agriculture so that our farm produce meets not only national but international quality standards, is produced at internationally competitive price and is sustainable. This, therefore calls for developing and imparting proper training to the farmers, which is possible only if the trainers which are produced by the agricultural universities are themselves properly educated in the advances in science of agriculture particularly at the Post-Graduate level where they have not only to learn the recent advances in their subject but have also to be trained in the modern and latest techniques in their disciplines so that they can participate and contribute in the development and advancement of agricultural science in India.

Keeping this in view, the ICAR which is vested with the responsibilities of guiding and coordinating agricultural education in the country, took several steps to ensure quality education to meet the ever changing national and global scenario in agriculture and allied sciences. One of these steps was to set up an Accreditation Board, which among other things is required to periodically assess the curricula of various educational programmes offered by the National Agricultural system and suggest modifications.

The second step in this connection was the constitution of Broad Subject Matter Area (BSMA) Committees for modification of P.G. Curricula and related issues. The BSMA Committee on Physical Sciences was constituted through ICAR Office Order No.1-3/98-Acdn./ Edn. Dated 30.11.1998 to examine the present Post Graduate (PG) course curricula and to modify and develop revised PG curricula in Agronomy, Agricultural Physics, Agricultural Meteorology, Soil Science and Agricultural Chemistry, Water Conservation and Irrigation, and Water Management. The BSMA Committee on Physical Sciences was constituted with Dr. M.S. Bajwa, Dean (PG), PAU, Ludhiana; Dr. D.K. Das and Dr. B.C. Panda, Ex-Heads, Division of Agricultural Physics, IARI; Dr. Banarsi Lal, Professor of Agronomy, GBPUAT, Pantnagar, Dr. R.S.Narang, Ex-Professor of Agronomy, PAU, Ludhiana as members and Dr. Rajendra Prasad, ICAR National Professor, Division of Agronomy, IARI as its Coordinator.

The first meeting of the BSMA Committee on Physical Sciences was held on 6th and 7th May, 1999 in the Division of Agronomy, IARI, New Delhi to develop the Course Curricula in different disciplines assigned to the committee. The meeting was attended by all its members and a number of scientists from IARI. It was unanimously decided that since Water Conservation and Irrigation, and water management are dealt by Agronomy, Soil Science and Agricultural Chemistry, and Agricultural Physics, separate disciplines in these subjects are not required. The Committee developed model syllabi for Agronomy, Agricultural Physics, Agricultural Meteorology, and Soil Science and Agricultural Chemistry. These syllabi were then sent to Heads of the various departments in SAUs for their comments and suggestions. After these comments and suggestions were received the courses were suitably modified. A workshop was then organized on April 6-7, 2000 in which a large number (76) of scientists from SAUs and other institutes were invited to go through the syllabi developed by BSMA Committee.

In modifying and developing P.G. courses in Agronomy the emphasis was on cropping systems, precision agriculture, modern tillage concepts including zero and minimum tillage,

emerging new crops such as medicinal and aromatic crops and on resource conservation and sustainable agriculture including organic farming.

In Soil Science and Agricultural Chemistry new or modified courses on soil pollution, land degradation and restoration, soil technology and systems approach in soil research have been proposed to take care of the environmental, natural resource conservation and sustainability issues.

The developments in Agricultural Physics are very fast with the introduction and applications of newer techniques and hence periodic revisions of the courses and curricula are necessary to keep the faculty and the students community abreast with these developments. The exercise for revision of these courses was therefore overdue and has been done.

Agricultural Meteorology is a new discipline and very few Agricultural Universities have this as a separate Department to impart education and training at PG level. The course content as well as approach and methodology have become outdated overtime. Moreover, there is no uniformity in courses. Since Agricultural Meteorology is a fast developing subject, many new aspects are added to the subject and new techniques have been developed with the advent and application of computers, satellite based weather data and crop simulation models. Hence a comprehensive and thorough revision of courses in Agricultural Meteorology had become necessary. New techniques of weather forecasting and its application to agriculture and agroadvisory services, statistical and computer added techniques to understand the crop weather interaction; and crop growth models, their validation and development have been included.

In all the disciplines, the courses have been modified to bring uniformity in course contents. Relevant books and other publications have been provided for most courses. These are however, those which came to the knowledge of the members of the BSMA Committee. It is hoped that the Professors at SAUs and other agricultural institutions will add many more books/publications/teaching materials to those already listed to develop a successful teaching programme.

We gratefully acknowledge the guidance and encouragement received from Dr R S Paroda, Secretary, (DARE) and DG, ICAR, and Chairman of Accreditation Board, in restructuring PG Curricula.

We are thankful to all the members of the BSMA Committee and Heads of Departments of Agronomy, Soil Science and Agricultural Chemistry, Agricultural Physics and Agricultural Meteorology of all SAUs, who sent their comments and suggestions and specially to those who personally participated in the workshop organized for the purpose. But for their help the revision and development of the syllabi in these disciplines could not have been possible.

We are grateful to Dr. P.K. Chhonkar, Head, Division of Soil Science and Agricultural Chemistry, IARI, Dr. R.P. Arora, Head, Dr.A.M. Moharir, Professor, and Dr. C.V.S. Shastri, Principal Scientist, Division of Agricultural Physics for the hard work they did.

Special thanks are due to Dr. Panjab Singh, Director, IARI and Dr. R.C. Gautam, Head, Division of Agronomy, IARI, for their valuable advise and facilities.

We hope that this document will serve as a guide and help in achieving uniformly higher standards of Post-Graduate Education in the concerned disciplines. The Education Division will appreciate comments and suggestions for improving and updating this publication in future.

RAJENDRA PRASAD
N.L. MAURYA
S.L. MEHTA

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1. AGRONOMY

A. Major

A.1.	**Core Courses**	**12 Credits**
		(L+P)
	1. Modern concepts in crop production	3+0
	1. Principles and practices of weed management	2+1
	3. Principles and practices of water management	2+1
	4. Soil fertility management and fertilizer use	2+1
	Seminar	**0+1 Credit**
A.2	**Optional courses**	**8 Credits**
	1. Agronomy of major field crops	4+0
	2. Dryland farming	2+1
	3. Crop ecology and geography	2+0
	4. Crop and seed physiology	2+1
	5. Soil conservation and watershed management	2+1
	6. Management of problem soils	2+1
	7. Fodder and forage crops	2+1
	8. Medicinal and aromatic crops	2+1
	9. Agronomy of vegetable crops	3+0
	10. Agroforestry	2+1
	11. Seed production agronomy	2+1
	12. Systems research and crop modelling	2+1
	13. Organic farming	2+1

B. Supporting Courses **14 Credits**

To be decided by the Students Advisory Committee

Total 35 Credits

A.1 Core Courses

Modern concepts in crop production **(3+0)**

Crop growth in relation to environment, agroecological zones of India; concept of potential yield and its realization; modern concepts in tillage: zero or minimum, conservation tillage etc., optimisation of plant population and planting geometry in relation to soil fertility, solar radiation and available moisture regimes; Mitscherlich, Baule and Inverse -yield-nitrogen laws, biotic and abiotic stresses; concept of ideal plant type; crop modelling for maximising crop yield; crop response production functions; cropping and farming systems for sustainable agriculture; organic farming-crop residue recycling and management; crop production under protective agriculture, precision agriculture; crop and growth analysis.

Suggested Readings

Baker, C.J., Saxton,K.E. and Ritchie, W.R. 1998. No tillage seeding - Science and Practice, CAB International, U.K.

Carroll, P.W. 1961. Crop Adaptation and Distribution, Eurasia Pub., New Delhi.

Gardner, F.P., Pearce, G.R. and Mitchell, R.L. Physiology of Crop Plants Scientific Pub. Jodhpur.

Lal, R. Tillage System in the Tropics-Management Options and Sustainability Indicators, FAO, Rome.

Palaniappan, SP and Sivarama, K. 1996. Cropping Systems in the Tropics- Principles & Management, New Age International Pub. P.211.

Reddy, K.R. and Hodges, H.R. Climate Change and Global Productivity. CABI, Pub.

Reddy, S.R. 2000. Principles of Agronomy, Kalyani Pub., New Delhi. pp.458.

Reddy, S.R. 2000. Principles of Crop Production. Kalyani Pub., New Delhi, pp.428.

Sankaran, S. and Mudaliar, T.V.S. 1997. Principles of Agronomy, The Bangalore Printing & Pub., Bangalore.

2. Principles and practices of weed management (2+1)

Classification and characteristics of weeds; special weed problems including aquatic and parasitic weeds. ecology and physiology of major weeds; ecophysiology of crop-weed competition including allelopathy; weed indices; principles and methods of weed control, concept of integrated weed management; weed control through bioherbicides, mycoherbicides and allelochemicals; herbicides history, development

and their classification; mode and mechanism of action of herbicides; herbicide selectivity, herbicide mixtures, adjuvants and safeners; degradation of herbicides in soil and plants; effect of herbicides in relation to environment; herbicide resistance in weeds and crops; weed management in major crops and cropping systems; weed shifts in cropping systems; control of weeds in non-cropped situations.

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.

Suggested Readings

Aldlrich, R.J. and Kramer, R.J. 1997. Principles in Weed Management. Panama Pub, New Delhi.

Ashton, F.M. and Crafts, A.S. 1981. Mode of action of herbicides, 2nd Edition. Wiley-Inter Science, pp.524.

Gupta, O.P. 2000. Weed Management - Principles and Practices. Agrobios, India Pub., pp.269.

Jimdahl, R.L. 1999. Fundamentals of Weed Science, 2nd Edition. Academic Press, New York.pp.556.

Mandal, R.C. 1990. Weed, Weedicides and Weed Control- Principles and Practices. Agro-Botanical Pub, Bikaner.

Rao, VS. 2000. Principles of Weed Science. Oxford and IBH. Pub., New Delhi. pp.555.

Subramanian, S., Ali, A.M. and Kumar, R.J. 1997. All About Weed Control, Kalyani Pub. New Delhi. pp.315.

3. Principles and practices of water management (2+1)

Water and its role in plants; water resources of India; major irrigation projects and extent of area and crops irrigated in India and different states; soil water movement and water availability, uptake, transport and transpiration in plants; soil-water-plant relationship; plant response to water stress; scheduling, depth and methods of irrigation; micro irrigation system; fertigation; management of water in controlled environments and polyhouses; water use efficiency; water management of crops and crop-

ping systems; soil, plant and meteorological factors determining water needs of crops; crop plant adaptation to moisture stress condition; quality of irrigation water; effect of saline water and soil salinity on plant-water relation and management of crops; excess soil water and plant growth; water management in problem soils; drainage requirements of crops and methods of field drainage, their layout and spacing, irrigability of lands.

Practical

Measurement of soil moisture using tensiometer, pressure plate and membrane; making of soil moisture characteristic curves; water flow measurement using different devices; determining soil profile moisture deficit and irrigation requirements; computation of water requirement of crops using modified Penman formula; measurement of water flux under saturated and unsaturated conditions; determination of infiltration rates and hydraulic conductivity.

Suggested Readings

Israelsen, O.W. and Jennsenn, V.E. 1962. Irrigation principles and practices. John Wiley and Sons, New Delhi. Chapman and Sons Ltd., London, pp.405.

Joseph, A.P., Dikshit, S.V., Reye, N.D. and Mildnner, W.F. 1972. Hand Book on Drainage of Agricultural Land Part I. Principles of Drainage- water management Division (Department of Agriculture). Ministry of Agriculture, New Delhi-1, pp.33.

Lenka, D. 1999. Irrigation and Drainage. Kalyani Publishers. L.D.H., New Delhi. pp.397

Michael, A.M. 1978. Irrigation: Theory and Practice. Vikas Publishing House, New Delhi, pp.801.

Paliwal, K.V. 1972. Irrigation with saline water. WTC, IARI, New Delhi. pp 198.

Prihar, S.S. and Sandhu, B.S. 1987. Irrigation of Food Crops- Principles and Practices. ICAR, New Delhi, pp.140.

Reddy, S.R. 2000. Principles of Crop Production. Kalyani Pub., New Delhi. pp.428.

4. Soil fertility management and fertilizer use (2+1)

Soil fertility and productivity; soil composition in relation to crop production — organic and inorganic constituents; essential plant nutrients; deficiency and toxicity symptoms of major and micronutrients and remedial measures; transformation and dynamics of major plant nutrients; kinds of fertilizers –straight, complex and bulk blended; methods of fertilizer application; crop response to nutrients; fertilizer use

efficiency, agronomic chemical and physiological; methods of increasing fertilizer use efficiency; nutrient interactions; fertilizer application in cropping systems- direct, residual and cumulative effects; integrated plant nutrient supply systems-organic manures, compost, green manures, vermi-compost, bio-fertilizers, crop residue and inorganic fertilizers; sustainable agriculture and soil fertility; fertilizers and environment; fertilizer use in problem soils; soil moisture -nutrients interactions.

Practical

Determination of soil pH, organic C, total N, available N,P,K & S in soils; total N,P,K & S in plants; interpretation of interaction effect and computation of economic and yield optima.

Suggested Readings

Cooke, G.W. 1967. The control of Soil Fertility. Crosby Lockwood, London. pp. 526.

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

Prasad, R. and Power, J.F. 1997. Soil Fertility Management for Sustainable Agriculture, CRC-Lewis, Boca Raton, Florida, pp.356.

Tandon, H.L.S. 1992. Management of Nutrient Interactions in Agriculture. FDCO Pub., New Delhi, pp.142.

Tisdale, S.L., Nelson, W.L., Beaton, J.D., Havlin, J.L. 1995. Soil Fertility & Fertilizers, Prentice Hall of India, Pub. New Delhi, pp.634.

A 2. Optional Courses

1. Agronomy of major field crops (4+0)

Origin, history, distribution, adaptation, classification, morphology, phenology, physiology, varietal improvement and production technology of rice, wheat, maize, sorghum, millets, important grain legumes (chickpea, pigeonpea, mungbean, urdbean and peas) and oilseed crops (rapeseed and mustard, groundnut, soybean, sunflower, safflower and castor), cotton, jute, sugarcane, potato and other important regional crops of the area; quality components and industrial uses of the main and by-products and their post-harvest handling for marketing.

Suggested Readings

Baekema, H.P. and Zaag, D.E.V.D 1990. Introduction to Potato Production. Pudoc, Wageningen pp.207.

Das, P.C. 1997. Oilseed Crops of India, Kalyani Pub., New Delhi, pp.273.

Lakshmikantam, N. 1983. Technology in Sugarcane Growing. 2nd Edition Oxford & IBH Pub., New Delhi pp.259.

Pal, M., Deka, J. and Rai, R.K. 1996. Fundamentals of Cereal Crop Production. Tata McGrahi Hill Pub., New Delhi. pp.400.

Prasad, R. (eds). 1999. A Text Book of Rice Agronomy, Jain Brothers, New Delhi, pp.238.

Prasad, R. (eds). 2001. Field Crop Production. ICAR, New Delhi (under preparation).

Singh, C. 1983. Modern Techniques of Raising Field Crops. Oxford & IBH, New Delhi. pp.523.

Singh, S.S. 1998. Crop Management. Kalyani Pub., New Delhi, pp.524.

Yadav, D.S. 1992. Pulse Crops. Kalyani Pub., New Delhi, pp.303.

2. Dryland farming (2+1)

Definition, concept, characteristics of dryland and rain-fed farming; significance and dimension of dryland farming in Indian agriculture; constraints limiting crop production in dryland areas; characterisation of environment for water availability; types of droughts; adaptation of crop plants to droughts; drought management strategies; preparation of appropriate crop plans for dryland areas; mid-season corrections for aberrant weather conditions; water-harvesting concepts, techniques and practices; use of mulches, kinds, effectiveness and economics; antitranspirants; soil and crop management techniques, tillage, seeding, fertilizer use, crop and varietal choice; concept of watershed management and its application in India.

Practical

Rainfall probability analysis for crop planning; measurement of soil and water losses; *in situ* soil moisture conservation practices; mulches, including live mulches for minimising evaporation losses; measures to manage prolonged drought during crop season; dry-seeding practices due to delayed monsoon rains; visit to a dryland research centre; study of on-going watershed management programmes and agroforestry systems.

Suggested Readings

Gupta, U.S. (Edited) 1995. Production and Improvements of Crops for Drylands. Oxford and IBH Publishing Company, Pvt. Ltd., New Delhi.

Jodha, N.S. Technology Options and Economic Policy for Dryland Agriculture. Concept Publishing Co. New Delhi.

Kanitkar, N.U. 1944. Dry Farming in India, ICAR, New Delhi.

Katyal, J.C. and Farrington, J. 1995. Research for Rainfed Farming, CRIDA, Hyderabad.

Ramaswamy, P. 1982. Dry farming technology in India. Agricole Publishing Academy, New Delhi.

Singh, R.P. 1988. Improved Agronomic Practices for Dryland Crops, CRIDA, Hyderabad.

Singh, S.D. 1998. Arid Land Irrigation and Ecological Management. Scientific. Pub., Jodhpur.

Singh, S.D. Water Harvesting in Desert. Manak Publications, New Delhi.

3. Crop ecology and geography **(2+0)**

Historical evolution, basic concepts and principles in crop ecology; response of crop plants to environment; factors (physical and social) determining crop distribution; classification of climate, bioclimatic zones; physiological limits of crop yield and variability in relation to the ecological optimum; photo and thermoperiodism; crop adaptation- geographic distribution of crop plants; adverse climatic effects and crop productivity; manipulation of development physiology of crops; crop phenology in relation to ecogeographical conditions; agro-climatic zones and agro-ecological regions of India; effects of global climate change on crop production.

Suggested Readings

Ambasht, R.S. 1986. A Text Book of Plant Ecology, 9th Edn.Students' Friends & Co., Varanasi, India, p. 351.

Kumar, H.D. 1992. Modern Concept of Ecology, 7th Edn., Vikas Publishing House Pvt. Ltd., New Delhi., New Delhi, p.377.

Lenka, D. 1998. Climate, Weather and Crops in India. Kalyani Publishers, New Delhi, pp.481.

Misra, K.C. 1989. Manual of Plant Ecology, Third Edn., Oxford &IBH Publishing Co. New Delhi.p.431.

Odum, E.P. 1975. Ecology, 2nd Edn. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, pp.249.

Sharma, P.D. 1998. Ecology and Environment, Rastogi Publications, Meerut, pp.660.

Singh, J. and Dhillon, S.S. 1984. Agricultural Geography. Tata Mcgrawhill Pub. Co. Ltd., New Delhi, pp.412.

Wilsie, C.P. 1961. Crop Adaptation and Distribution, Eurasia Publishing House (Pvt.) New Delhi, pp. 448.

4. Crop and seed physiology (2+1)

Physiology of seed development; dormancy-causes and measures to break dormancy; viability and germination of seed; changes in seed during storage; Yield concepts and measurements; yield contributing components of crop-plant type, its morphological and physiological parameters; yield, photosynthesis and respiration in relation to dry matter production in crop community; distribution and translocation of photosynthates in relation to yield; productivity maximization and factors limiting the realization of potential yield, chemical regulators of growth; stress physiology and resistance to drought and salinity; crop quality.

Practical

Dormancy of crop-seeds; tests of dormancy; determining photosynthesis and respiration; test of deciding physical and physiological parameters of plant types; plant growth regulators and their use.

Suggested Readings

Gardner, F.P., Pearce, R.B. and Mitchell, R.L. 1985. Physiology of crop plant. Scientific Pub., Jodhpur.

Pandey, S.N. and Sinha, B.K. 1995. Plant Physiology. Vikas Publishing House, 576 Masjid Road, Jangpura, New Delhi.

Salisbury, F.B. and Ross, C.W. 1986. Plant Physiology. CBS Publishers and Distributors, Darya Ganj, New Delhi-2.

Taiz, L. and Zeiger E. 1992. Plant Physiology. Benjamin/Commings Publishing, California.

5. Soil conservation and watershed management (2+1)

Soil erosion- definition, nature and extent of erosion; types of erosion, factors affecting erosion; soil conservation –definition, methods of soil conservation- agronomic measures, contour cultivation, strip cropping, cover crops, vegetative barrier; improved dry farming practices; mechanical measures -bunding, gully control, bench terracing; role of grasses and pastures in soil conservations; wind breaks and shelter

belts; watershed management-definition, objectives, concepts, approach, components, steps in implementaion of watershed; development of cropping system for watershed areas; alternate land use systems; agroforestry, ley farming; *Jhum* management - basic concepts, socio-ethnic aspects, its layout, drainage considerations and agronomic management; rehabilitation of abondoned *jhum* lands and measures to prevent soil erosion.

Practical

Study of different types of erosion; field studies of different soil conservation measures; runoff and soil loss measurement; laying out runoff 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, H.R. and Roy, D. 1984. Principles of Soil Conservation and Water Management. Oxford and IBH Publishing Co., New Delhi.

Datta, S.K. 1986. Soil Conservation and Land Management. International Book Distributors, Dehradun, India.

Dhruvanarayana, V.V. 1993. Soil and Water Conservation Research in India. ICAR, New Delhi.

Ghumare, N.K. 1962. Studies on Behaviour of Contour Bunds. Soil and Water Conservation in India. 10:27-32.

Gurmel Singh, C. Rambabu and Subhas Chandra. 1981. Soil loss prediction research in India, CSWCRFTI, Dehradun, India.

Gurmel Singh, C. Venkataraman, G., Sastry,B. and Joshi, P. 1990. Manual of Soil and Water Conservation Practices. Oxford and IBH Publishing Co., New Delhi.

Murthy, V.V.N. 1995. Land and Water Management Engineering. Kalyani Publishers, Ludhiana, India.

Rama Rao, M.S.V. 1962. Soil Conservation in India, ICAR, New Delhi.

Reddy, S.R. 1999. Principles of Agronomy.Kalyani Publishers, New Delhi, pp.458.

Sakara Reddi,G.H. and Sithapathi Rao, C. 1967. A Manual on Soil Conservation. Department of Agriculture, Government of AP, Hyderabad, India.

Tripathi, R.P. and Singh, H.P. 1993. Soil Erosion and Conservation. Willey Eastern Limited, New Delhi.

Wischmeier, W.H. and Smith, D. D. 1978. Predicting Rainfall Erosion Loss- A guide to conservation planning, USDA Hand Book No. 537.

Yellamanda Reddy, T. and Sankara Reddi, G.H. 1992. Principles of Agronomy, Kalyani Publishers, Ludhiana, India.

6. Management of problem soils (2+1)

Origin, nature, properties and distribution of saline, sodic, calcareous, acid and water logged soils; plant response to soil reaction; nutrient imbalance in problem soils; extent of damage to crops; crop tolerance to salinity, sodicity, acidity and water logging; reclamation of problem soils; role of soil amendments and soil drainage; agronomic practices in relation to problem soils; cropping pattern for problem soils.

Practical

Determination of soil pH, electrical conductivity, CEC, different anions and cations present in soil; lime requirement; visit to problematic areas to acquaint with production constraints.

Suggested Readings

Mohsin, M.A., Sarkar, A.K. and Mathur, B.S. 1995. Acid Soil Management Kalyani Publishers, New Delhi, pp

Singh, K.N., Kumar, A. and Sharma, D.K. 1998. Management of Problem Soils. *In.* Yadav, R.L., Singh, P., Prasad, R. and Ahlawat, I.P.S. (ed.). Fifty years of Agronomic Research in India, Indian Society of Agronomy, New Delhi.

Somani, L.L. 1996. Crop Production in Acid soils. Agrotech Publishing Academy, Udaipur.

USDA. 1954. Diagnosis and Improvement of Saline and Alkali Soil USDA. Handbook –60, USDA, Washington, DC, pp.160.

7. Fodder and forage crops (2+1)

Adaptation, distribution, varietal improvement, Agrotechniques and quality aspects including anti-quality factors of important fodder crops like teosinte, maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucern and clovers; year round fodder production and management, preservation and utilization of forage and pasture crops; 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 of poor quality fodder, Economics of forage cultivation.

Grasslands of India and their importance, principles of grassland ecology, economic aspect of grasslands, their problems and management; improvement of grasslands; pasture grasses and legumes for improving soil fertility; importance, classification and advantage of pastures; establishment of pastures, their improvement and renovation; ley farming. Agrotechnology for pasture grasses and forage legumes for different agro-ecological situations, Grazing management. Nutrient Management.

Practical

Exercises on farm operations in raising fodder crops; exercises on canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica cellulose etc. of various fodder and forage crops and antiquality components like HCN in *sorghum* and such factors in other crops; hay and silage making and economics of their preparation.

Suggested Readings

Wheeler, W.A. 1950. Forage and Pasture Crops. D. Van Nostrand Company Inc., New York.

Whiteman, P.C. 1980. Tropical Pastures. Oxford University Press, Oxford.

Narayanan, T.R. and Dobadghao, P.M. 1972. Forage Crops of India, ICAR, New Delhi.

Singh, P. and Srivastava, A.K. 1990. Forage Production Technology, IGFRI, Jhansi.

Tejwani, K.G. 1994. Agroforestory in India. Oxford & IBH Publishing, New Delhi.

Dwivedi, A.P. 1992. Agroforestry- Principles. Oxford & IBH Pub., New Delhi.

Chatterjee, B.N. 1989. Forage Crop Production- Principles & Practices. Oxford & IBH Pub. New Delhi.

Mehra, K.L. 1978. Oats. ICAR, New Delhi.

8. Medicinal and aromatic crops (2+1)

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; climate and soil requirements; cultural practices; yield and important constituents of medicinal and aromatic plants (Isabgol, citronella, palmarosa, *Rauwolfia*, poppy, *Asaphoetida*, *Nux vomica*, rosadle, mentha, basil, geranium etc).

Practical

Identification of crops based on morphological and seed characteristics; raising of

herbarium of M&A plants; quality characters in medicinal and aromatic plants; methods of analysis of some essential oils and other chemicals of importance in M&A plants.

Suggested **Readings**

Chadha, K.L. and Gupta, R. 1995. Advances in Horticulture Vol.11. Medicinal and Aromatic Plants, Malhotra Pub., New Delhi.

Farooqi, A.A. and Sreeramu, B.S. 2000. Cultivation of Medicinal & Aromatic Plants, University Press, Hyderabad (in Press).

Handa, S.S. 1984. Cultivation and Utilization of Aromatic Plants, RRL, CSIR, Jammu.

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

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

Hussain, A. 1994. Essential Oil Plants and their cultivation, CIMAP, Lucknow

Kumar, N., Md. Abdul Khader, J.B.M. Rangaswami and Irulappan. 1997. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH Pub., New Delhi.

9. Agronomy of vegetable crops **(3+0)**

Origin, history, distribution, adaptation, classification, varietal improvement, morphology, production technology, quality components and post harvest handling of important vegetable crops including *solanaceous crops:* tomato, brinjal, chillies, bell pepper; *cole crops;* cauliflower, cabbage, knol-khol; *root crops:* radish, turnip, carrot, beet, colocasia, yam, tapioca; *bulb crops:* onion, garlic; legumes: *Beans:* peas, frenchbean, cowpea, cluster bean; *cucurbits:* cucumber, bottle gourd, bitter gourd, sponge gourd, ridge gourd, tinda, okra, *salad crops:* lettuce, celery; *leafy vegetables:* spinach, fenugreek, amaranth etc.

Suggested Readings

Barooah. S. 1993. Vegetable Growing in India. Kalyani Publishers, N. Delhi.

Bose, T.K., M.G. Som and J. Kabir (Editor) 1986. Vegetable Crops. Naya Prakash, Calcutta, p. 206.

Choudhury, B. 1967. Vegetables. National Book Trust of India, New Delhi.

Hazra, P. and Som M.G. 1999. Technology for Vegetable Production and Improvement. Naya Prakash, Calcutta. pp.206.

10. Agroforestry (2+1)

Definition, concept, scope; historical perspective, agroforestry systems; agri-silviculture, silvipasture, agri-silvipasture, agri-horticulture, aqua-silviculture; alley cropping and energy plantation; agroforestry systems for forage and fuel wood production, resource conservation; improvement of degraded lands; biological diversity and sustainable agriculture and environmental protection; associative influence in relation to above-ground and underground interferences; allelopathy in various agroforestry systems-direct and indirect effect; efficient agroforestry designs/models for different agroclimatic conditions; tree-crop-animal relationship; food-fodder-fuel systems; productivity and sustainability; alternate land use systems through agroforestry; social acceptability and economic viability; agroforestry interventions with multipurpose tree species; Nutrive value of tree leaf, economics of AF systems.

Practical

Identification of various tree species, planting methodology and techniques, study of litter fall and biomass deposits, organic matter and nutrient conservation; poloroding and defoliation, coppicing; light and temperature measurement; visit to a institute related to agroforestry.

Suggested Readings

Hegde, H.G., Relwani, L.L. and Kelkar, V.D. (ed). 1989. Promotion of Fodder of Fuelwood Trees. BAIF Development Research Foundation, Pune.

Jha, L.K. and Sen-Sarma, P.K. 1997. A Manual of Forestry Extension Education. APH Publishing Corp. New Delhi.

Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer, Netherlands.

Pathak, PS. and Roy M.M. 1994. Agroforestry Systems for Degraded Lands. Oxford & IBH Publishing, New Delhi.

Tejwani, K.G. 1994. Agroforestry in India, Oxford & IBH Pub., New Delhi.

11. Seed production agronomy (2+1)

Seed production techniques and agronomical practices for important crops-cereals, pulses, oilseeds, fibre crops and fodder crops; seed industry in the country and role of various agencies seed morphology seed multiplication chain, seed purity seed health, Dormancy, seed vigour; Hybrid seed production, seed treatments, seed viability, seed quality; physiology of seed germination; seed testing for germination and seedling evaluation; seed certification, processing, grading and storage; distribution and marketing, store grain pests.

Practical

Seed quality on the basis of purity and germination; roguing; detasseling and familiarization with seed processing equipments; materials and precautions for seed storage; comparison of farmer's saved seed with certified seed.

Suggested Readings

Agrawal, R.L. 1995. Seed Technology. Oxford & IBH Pub., New Delhi.

Agrawal, P.K. and Dadlani, M. 1992. Techniques in Seed Science & Technology, South Asian Pub., New Delhi.

Dahiya, B.S. and Rai, K.N. 1997. Seed Technology. Kalyani Pub., New Delhi.

Sen, S. and Ghosh, N. 1999. Seed Science & Technology, Kalyani Pub., New Delhi.

12. Systems research and crop modelling (2+1)

Systems- classification, flow charts, input- output relationships; methods- types and phases of development; modelling techniques- states, rates and driving variables, feedbacks, relational diagrams, methods of integration; crop modelling- methods for crop-weather interaction, water and nitrogen stress effects, insects pests interactions, datarequirement&limitations.

Practical

Related to theory on a simulation language; modelling techniques; hands on with crop models for assessment of growth and yield of crops; water and nutrient management and climate change and variability components. (to be offered in collaboration with related department (s)).

Suggested Readings

Gordan, G. 1992. System simulation. 2nd edn. Prentice Hall of India, New Delhi.

Kropff, M.J. and Vaan Laar, H.H. (ed.) 1993. Modelling Crop Wed Interactions. ISBN.

Mathews, R.B., Kropff, M.J., Bachelet, D. and Vaan Laar, H.H. (ed) 1993. Modelling the Impact of Climate Change on rice production in Asia. CAB International IRRI, Wallingford & Oxon. U.K.

Penning de Vries, F.W.T. and VanLaar, H.H. (ed). 1982. Simulation of plant growth and crop production. Wageningen Centre for Agril. Pub. & Documentation, Netherlands.

Zeigler, Bernard P. 1976. Theory of Modeling and Simulation. John Wiley and Sons, Inc, New York.

13. Organic Farming (2+1)

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, water use efficiency; Soil fertility- nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, biofertilizers; Farming systems- crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity, control of weeds, diseases and insect pests; Animal Husbandry, dairy farming, sheep and goat and piggery etc. Integrated pest management — biological agents and pheromones, biopesticides; Socio-economic impacts; Marketing and export potential- inspection, certification, labelling and accreditation procedures; Organic farming and national economy.

Practical

Aerobic and auaerobic methods of making compost, making of vermi compost; Identification and nursery raising of important agroforestry trees and trees for shelter belts; Efficient use of biofertilizers- technique of treating legume seeds with Rhizobium cultures, use of *Azotobacter, Azospirullum* and PSB cultures in field; Visit to a organic farm; Quality standards, inspection, certification and labelling and accreditation procedures for farm produce from organic farms.

Suggested Readings

Ananthakrishnan, T.N. (editor) 1992. Emerging Trends in Biological Control of Phytophagous insects. Oxford & IBH, New Delhi, p.255.

Gaur, A.C. 1982. A Manual of Rural Composting. FAO/UNDP Regional Project Document, FAO, Rome, pp. 102.

Lampin, N. 1990. Organic Farming. Farming Press Books, Ipswitch, U.K.

Palaniappan, S.P and Anandurai, K. 1999. Organic Farming- Theory and Practice, Scientific Pub., Jodhpur, pp.257.

Reddy, M.V. (editor) 1995. Soil organism and Litter decomposition in the Tropics. Oxford & IBH, New Delhi. pp.274.

Singh, SP (editor) 1994. Technology for Production of Natural Enemies, Project Directorate of Biological Control, Bangalore, pp.220.

Trivedi, R.N. 1993. A Text Book of Environmental Sciences, Anmol Pub, New Delhi, pp.410.

Veeresh, G.K., Shivashankar, K. and Suiglachar, M.A. 1997. Organic Farming and Sustainable Agriculture, Association for Promotion of Organic Farming, Bangalore.

Venkata Rao, B. V. 1995. Small farmer focussed integrated rural development: Socio-economic environment and legal perspective: Pub.3, Parisaraprajna Parishtana, Bangalore, pp.12.

WHO 1990. Public Health Impact of Pesticides used in Agriculture, WHO, Paris.

Woomer, PL. and Swift, M.J. 1994. The Biological Management of Tropical Soil Fertility, T.S.B.F. & Wiley.

2 AGRICULTURAL PHYSICS

A.	Major	
A.1	Core Courses	12 credits
	1. Basic concepts of physics	2+1
	2. Fundamentals of soil physics	2+1
	3. Principles of biophysics	2+1
	4. Fundamental of agrometeorology & climatology	2+1
	Seminar	0+1 credit
A.2	Optional Courses	8 credits
	1. Physics of soil and water conservation	2+1
	2. Soil physical environment and plant growth	2+1
	3. Principles of remote sensing and its application in agriculture	2+1
	4. Micrometeorology	2+1
	5. Evapotranspiration	2+1
	6. Principles of modelling in agriculture & biology	2+1
	7. Remote sensing of environment	2+1
	8. Techniques of biophysics	2+1
	9. Nuclear techniques in agriculture and biology	2+1
	10. Mathematics in agriculture & biology	2+1
B.	Supporting courses	**14** credits
	To be decided by the Students Advisory Committee	
		Total 35 credits

A.1 Core Courses

1. Basic concepts of physics **(2+1)**

Classical Mechanics: Space, time and matter as physical entities; classical motion-velocity, acceleration; degrees of freedom; inertial frames of reference; free motion; relative and absolute motion; classical relativity principle-Galilean transformations; principle of action at a distance; Newton's laws of motion; force, field and potential; space homogeneity and conservation of linear momentum; space isotropy and conservation of angular momentum; time homogeneity and conservation of energy; time isotropy and reversibility of equations of motion.

Relativistic Mechanics: Constancy of velocity of light; invariance of space-time separation; corollaries of Lorentz transformations-length contraction, time dilatation; mass, energy and momentum of a relativistic particle; particle with zero mass.

Electromagnetic Field: Classical electrodynamics- electric charge; field of a charged particle at rest; potential; field of a system of charges-superposition principle; law of conservation of charge; energy of system of charges; Maxwell's equations; fields in vacuum; electromagnetic waves-plane waves, monochromatic waves, coherent waves; interference, diffraction and polarization of waves; wave radiation; geometrical optics, optical instruments, magnification and resolving power.

Gravitation: nature of gravitational field; principle of equivalence; general relativity and the universe.

Quantum Mechanics: atomic phenomena; wave-particle duality-de Broglie wavelength; simultaneous measurement of canonical conjugate variables-Heisenberg's uncertainty principle; Schrodinger's matter-wave equation; zero point energy; the tunnel effect; space and time symmetry; internal degrees of freedom-spin; Pauli's exclusion principle; exchange effect; application to atoms in the periodic table.

Cosmic rays and Elementary Particles: classification of elementary particles and their interaction; conservation laws in the physics of elementary particles.

Nuclear Physics: atomic nuclei as the bound states of nucleons; isotopes, isotones and isobars; nuclear structure and stability; radioactive disintegrations, half life, radio activity detectors and counting instruments.

Statistical Physics: macroscopic bodies; phase space; statistical laws; statistical equilibrium; statistical distribution; Gibb's distribution; conservation laws in statistical physics: system of indistingushable identical particles- Bose and Fermi statistics; laws of thermodynamics; entropy; thermodynamic relationships; temperature, pressure, equation of statge; state of matter- the ideal gas, Clausius-Clapeyron's equation; liquid state-viscosity, surface tension, superfluidity; solid state-crystalline and amourphous state; dielectrics, semiconductors, conductors and superconductors; Stellar states of matter.

Mechanics and electrodynamics of continuous media: fluid dynamics streamline and vortex motion; Bernauli's theorem; elasticity; vibrations; electromagnetic fields in material media; macroscopic electrical and magnetic properties of matter.

Practical

In general the practical would be developed and set up by the instructors depending upon the available equipments. However some suggested practicals are as follows; Measurements on motion of different types; surface tension; viscosity; density; sedimentation rates; centrifugation; measurement of electrical field; potential; potentiometer; wheat stone's bridge; electrical resistance measurement; dielectric measurement; capacity measurement; conduction currents; internal resistance; Interference of light-Newton's Ring experiment; Fressnel's Bi-prism experiment; spectrometers; prisms as spectral dispersing materials; diffraction gratings; spectrophotometer; Beer-Lambert's law; transmittance / absorbance curves with changes in wavelengths; polarimeter and optical rotation; light intensity measurements; photometers; pyranometer; albedometer; net radiometer;

Suggested Readings

Condon, E.U. and Shortley, G.H. 1935. Theory of Atomic Spectra, Cambridge University Press, New York.

Glasstone, Samuel, 1967. Source Book of Atomic Physics, Affiliated East West Press, New Delhi, pp 883

Herzberg, G, 1944. Atomic Spectra and Atomic Structure, Dover, New York.

Krishna, Ram, 1960. General Properties of Matter, Kitab Mahal, Allahabad, pp 666

Mathur, D.S., 1956. Elements of Properties of Matter, S Chand & Co, New Delhi, pp 604.

Rajam, J.B., 2000. Atomic Physics, S Chand & Co, New Delhi, pp1279.

Sengupta, P.C & Kohli, B.S, 1967, Text Book of Physics, Vol I,II, Kitab Ghar, New

Simon, Ivan, 1966, Infrared Radiation, Affiliated East West Press, New Delhi.

Slater, John C. 1960. Quantum Theory of Atomic Structure, Vol.1, McGraw Hill, New York.

Zemansky, M.W. 1966. Temperatures Very Low and Very High, Affiliated East West Press, New Delhi.

2. Fundamentals of soil physics (2+1)

Soil as polyphase system, soil matrix, particle size distribution, structure of clay-minerals- nomenclature and system of classification; Soil structure, genesis, classification and evaluation, porosity & pore size distribution, soil water and various force fields for its retention, soil water availability, thermodynamics of soil water, measurement of soil water content/potential, saturated and unsaturated movement, infiltration, redistribution, evaporation; Field water balance, soil aeration and its characterization; thermal regimes of soils; soil consistency; soil strength & tilth; physical properties of soil in relation to soil erosion & land capability; spatial variability, analysis of soil physical properties; use of isotopes and radiation in soil physical investigation.

Practical

Particle size analysis by hydrometer and international pipette method; determination of bulk density, particle density and mass volume relationships of soils of various types; soil water retention characteristics; aggregate analysis- by wet and dry sieving methods; estimation of Atternberg constants and soil strength; determination of saturated and unsaturated hydraulic conductivity; determination of infiltration rates; measurement of soil water content and soil water potential.

Suggested Readings

Baver, L.D., Gardner, W.H. and Gardner, W.R. 1972. Soil Physics, John Wiley & Sons.

Hanks, R.J. and Ascheroft, 1980. Applied Soil Physics, Springer-Verlag, Berlin.5.

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

Hillel, D. 1982. Introduction to Soil Physics, Academic Press, New Delhi.

Hillel, D.1998, Environmental Soil Physics, Academic Press, New Delhi.

Khonke, Helmut, 1968. Soil Physics, McGraw Hill Publication

Kirkham, D and Powers, W.L. Advanced Soil Physics 1972. Wiley Interscience, New Delhi.

Oswal, M.C, 1994. Soil Physics, Oxford & IBH, New Delhi.pp.360.

3. Principles of biophysics (2+1)

Structure and function of biological macromolecules and their organization; membrane structure and function; types of binding forces; bioenergetics; biophysical features of living cells; viruses; survey of experimental techniques for the study of

biomolecular structure and function- sedimentation, ultracentrifugation, electrophoresis, chromatography, aminoacid and nucleotide sequence analysis; diffusion, osmometry, viscometry, conductometry, dielectrometry, polarography, microcalorimetry; microscopy- polarized light microscopy, phase contrast microscopy, interference microscopy, electron microscopy; atomic force microscopy, scattering/ diffraction of light, X- rays, electron and neutron; birefringence, optical rotatory dispersion and circular dichroism; spectroscopy- UV, visible, IR, LASER, EPR, NMR and Mossebauer.

Practical

Sample component separation by various physical techniques, sedimentation, centrifugation, electrophoresis, chromatography(liquid / paper); optical rotation by sugars using polarimeter; measurement of birefringence, refractive index; 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 ultraviolet spectral regions.

Suggested Readings

Birnie, G. D and Rickwood, R. 1978. Centrifugal Separations in Molecular and Cell Biology, Butterworths, London.

Cambell, G.S, 1997. An Introduction to Environmental Biophysics, Springer Verlag, Berlin.

Casey, E.J, 1962. Biophysics, Concepts and Mechanisms, Van Nostrand Reinhold Co. New York.

Elsasser, W.M, 1958. The Physical Foundations of Biology, An analytical study, Pergamon Press, London.

Glick, D. (editor) 1967. Methods of Biochemical Analysis, vol. 15, Interscience, New York.

Hoppe, W., Lohmann, W, Mark, H. and Hubert, Z. 1983. Biophysics, Springer Verlag, Berlin.

Narayanan, P. 1998. Essentials of Biophysics, New Age International Publishing, New Delhi.

Neuhoff, V. 1973. Molecular Biology, Biochemistry and Biophysics, vol. 14, pp.205. London; Chapman and Hall: Berlin, Heidelberg and New York; Spriknger-Verlag

Pain, R.H and Smith, B.J, (eds). 1975. New Techniques in Biophysics and Cell Biology, Wiley, London.

Rashevsky, N. 1960. Mathematical Biophysics, Physico-Mathematical Foundations of Biology, Vol.2, Dover Publications, New York.

4. Fundamentals of agrometeorology and climatology (2+1)

Sun and earth; seasons; solar radiation and laws of radiation; heat balance of the earth and atmosphere; meteorology and climatology; instruments for measurement of meteorological elements; optical phenomena in the atmosphere, agromet observatory; variation of pressure and temperature with height; vapour pressure; psychrometric equation; saturation deficit; potential temperature; pressure gradient; cyclonic and anticyclonic motions; clouds and their classification; origin and accumulation of electrostatic charges on clouds, thunder lightening precipitation processess; artificial rain making; thunderstorm and dust storm, hail, mist, fog and dew; local wind system; land and sea breeze circulation; mountain and valley winds; weather charts; forecasting methods-short, medium and long range forecasting techniques, numerical weather prediction; El Nino and southern oscillations. Atmospheric pollution and its effect on climate.

Weather and climate; seasonal distribution of climatological elements over latitudes; climatic classification: Koppen and Thornthwaite systems; types of climate: humid and dry climates; climatic change and global warming; agroclimatic indices; agroclimatic zones; different agroecological zones for India; physical climate, climatology of India: monsoons, rainfall variability; atmospheric and soil drought; arid and semi-arid regions; frequencies of disastrous weather events in different regions; climatological factors and their effects on crop pests and diseases, crop growth and yield.

Practical

Agromet observatory-different classes of observatories(A,B,C). Site selection and installation procedures for meteorological instruments; measurements of weather parameters, their reading and recordings; calculation of daily, weekly, monthly means/ totals of weather data climatic normals; weather chart preparation and identification of low pressure systems and ridges.

Suggested Readings

Byers, H.R. 1959. General Meteorology, McGraw Hill Inc, New York

Chang Jen Hu, 1968. Climate and Agriculture, Aldine Publishing Co, Chicago.

Gates, D.M. 1968. Energy Exchange in Biosphere, UNESCO, Paris.

Ghadekar, S.R, 1991. Meteorology, Agromet Publishers, Nagpur.

Haurwitz, B. and Austin, J.M., 1944, Climatology, McGraw Hill Inc.,New York. pp 410.

ICRISAT Climatic Classification-A Consultants Meeting, 1980,ICRISAT-Hyderabad, India, pp.153.

Lal D.S., 1989. Climatology, Chaitanya Publishing Home, Allahabad, pp 420.

Munn, R.E, 1970. Biometrological methods, Academic Press, New York.

Patterson, S., 1958. Introduction to Meteorology, McGraw Hill Inc, New York, pp 327.

Trewartha G. T. 1954. An Introduction to climate, McGraw Hill Inc., New York, pp 395.

A.2 Optional Courses

1. Physics of soil and water conservation (2+1)

Degradation of land and environment and role of soil and water conservation.

Physics of soil erosion by water-effect of climate and hydrology; rainfall energy, impact and detachment; rainfall erosivity indices; soil erodibility, soil physical properties affecting erosion; topography and soil surface cover; universal soil loss equation, its modification, estimation of soil loss and its prediction; erosion measurement on watershed basis; run off estimation and prediction using conventional and remote sensing technique; types of soil erosion and its control.

Physics of wind erosion-wind velosity, initiation and movement of soil particles; saltation, suspension and surface creep and mechanics involved; soil physical properties affecting wind erosion; wind erosion equation and its computation, control of wind erosion.

Water harvesting and recycling; hydrologic assessment; rain water management procedures; storage losses, seepage and its controls, watersheds characterization and management using remote sensing and GIS; desertification and its control.

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, gullies, ravines and hilly areas; Soil physical properties in conservation forestry, agroforestry and grasslands.

Practical

Visit to nearby watershed and identification and characterization of various components of watershed and its management including determination of annual cummulative erosivity, estimation of soil erodibility and other erosion indices; calculation of peak rate of run off from the watershed and watershed survey for management and planning.

Suggested Readings

Arakeri, H.R, Chalam,G.V, Satyanarayana, P. and Donahue, R.L, 1962. Soil management in India, Asia Publishing House, Bombay.

Bennett, H.H. 1955. Elements of soil conservation, McGraw Hill, New York.

Hillel, D. 1998. Environmental Soil physics, Academic Press,

Hockensmith, R.D. (editor). 1960. Water and Agriculture, Am Assoc. for Advancement of Sci, Publication No. 62.

Smith, G.H. (editor) 1962. Conservation of natural resources, Wiley & Sons, New York.

Stallings, J.H. 1957. Soil conservation, Prentice Hall, Inc, Eaglewood Cliffs, NJ.

Tejwani, K.G.,Gupta, S.K. and Mathur, H.N., 1975. Soil and Water Conservation Research, Indian Council of Agricultural Research, New Delhi.

USDA. 1954. A Manual of Conservation of Soil and Water, USDA, Soil Conservation Service, Handbook No. 61.

2. Soil physical environment and plant growth (2+1)

Composition of soil physical environment in relation to plant growth and development, soil aggregates, soil structure and fabric, soil strength, surface and subsurface mechanical impedance to seedling emergence and root development, soil conditioners; soil-water-plant relationship-seed water uptake, root growth and development, water flow in soil-plant-atmosphere continuum, plant water status and stress development. Water use efficiency, water use-yield relationships. Soil-air-plant relations, critical oxygen concentration and factors affecting; soil temperature in relation to germination of seeds and growth and development of plants. Soil and plant criteria for soil irrigability and irrigation scheduling of crops. Field water balance for irrigation under adequate and inadequate water supply conditions. Irrigation and nutrient interaction. Soil physical properties in relation to erosion, water logging, Tillage in relation to soil physical properties, root and crop growth, salt build-up and their improvement for crop production. Soil based indices for sustainability evaluation. Crop growth simulation models and their applications.

Practical

Measurement of soil surface and sub-surface mechanical impedance; determination of root- weight- density and root-mass-density; measurement of soil and plant water potentials-use ofpsychrometer for water stress measurements; measurement of Oxygen Diffusion Rate; determination of soil moisture content by time domain refractometry; measurement of soil water flux and K (6) relations by internal drainage methods; determination of soil-moisture content by neutron moisture meter.

Suggested Readings

Anderson, S.H and Hopmans, J.H. (eds). 1994. Special Publication No. 36, Tomography of Soil-Water- Root Processes, Soil Science Society of America, Madison, Virginia.

De Vries, D.A and Afghan, N.H. (eds.). 1974. Heat and Mass Transfer in the Biosphere, Halsted Press-Wiley, New York.

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

Hillel, D. (editor). Optimizing Soil Physical Environment Towards Greater Crop Yields, Academic Press, New York.

Middletone, H.E. 1930. Properties of soil which influence soil erosion, USDA Tech Bull. 178.

Nobel, P.S. 1974. Introduction to Biophysical Plant Physiology, Freeman, san Francisco, California.

Philips, J. R. 1966. *In*- Proc. UNESCO Symposium -Water in the unsaturated Zone, Practice, Special Publication No.30, Soil Science Society of America.

Stanhill,G. 1976. Vegetation and atmosphere, Vol II, Ed. J.L., Monteith, Academic Press.

Van Wijk, W.R. 1963. Physics of Plant Environment, North-Holland, Amsterdam. Wageningen, Netherlands.

3. Principle of remote sensing and its applications in agriculture (2+1)

Basic components of remote sensing: signals, sensors and sensing systems; active and passive remote sensing; characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions; imaging and non imaging systems; framing and scanning systems; resolution of sensors; sensors platforms, their launching and maintenance; data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction; microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

Digital techniques for crop discrimination and identification; crop stress detection-soil moisture assessment, inventory of ground water & satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation; 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; demonstrations of case studies; hands on training.

Suggested readings

Colwell, R.N.(editor). Manual of Remote Sensing - Vol. 1 & II, Am Soc. Photogrammetry, Virginia.

Curan, P.J. Principles of Remote Sensing, ELBS/Longman.

Jain, A.K. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India, Saddle river, N J.

Kamat, D.S and Sinha, S.K (eds). Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June 22-23, 1984, ICAR & ISRO.

Lillesand T.M and Kiffer, R. W. Remote Sensing and image interpretation, John Wiley & son., Inc, New York.

Majumdar, K.L et.al, 1983. Selection of spectral bands and their widths for the Indian Remote Sensing satellite (IRS). RSP-1P/TN03/83, Space Applications Centre, Ahmedabad-380 053.

Sabins, F.F. 1997. Remote Sensing-Principles and Interpretation, 3rd ed. WH Freeman and Co.

Schowengerdt, R.A. 1997. Remote Sensing, Models and Methods for Image Processing, 2nd edn. Academic Press, London.

4. Micrometeorology **(2+1)**

Properties of atmosphere near the earth's surface. 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, variations in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth. 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—leaftemperature and its biological effects. Heat transfer near and within the ground. Influence of topography on

microclimate. Shelter belts and wind breaks, micro climate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates. Instruments and measuring techniques in micrometeorology. Effects of ambient weather conditions on growth, development and yield of crops. Crop-weather relations, statistical regression equations and crop growth models.

Practical

Measurement of global radiation 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-short crops and tall crops; energy balance over crops and FAI and biomass estimation.

Suggested Readings

Chang, J.H. 1968. Climate and Agriculture, Aldine Publishing Co.Chicago.

Evans, L.T. 1963. Environmental Control and Plant Growth, Academic Press, New York.

Gates, D.M. 1968, Energy Exchange in the Biosphere, UNESCO, Paris.

Grace, John 1983. Plant Atmospheric Relationships: Outline studies in Ecology, Chapman & Hall, New York, pp92.

Munn, R.E, 1970. Biometeorological Methods, Academic Press, New York.

Rose, C.W. 1996. Agricultural Physics, Pergamon, London

Sellers, W. 1967. Physical Climatology. The University of Chicago Press, Chicago.

5. Evapotranspiration (2+1)

Basic laws of radiation; radiation interaction in plant environment; energy balance in atmosphere; crop canopy atmosphere near the ground; theories ofevapotranspiration and their comparison; application under different agroclimatic conditions; potential and actual evapotranspiration; influence of microclimate-plant, soil and cultural factors; technique of lysimetry in measuring actual evapotranspiration; yield functions; water use efficiency and scheduling irrigation based on evapotranspiration; techniques for measurement of radiation and energy balance, Hydrological cycle..

Practical

Measurement and evaluation of radiation components; computation and comparison of evapotranspiration by different methods; energy balance method; acrodynamic method; Pennman method; remote sensing and other methods; measurement of wind and temperature profiles near the ground.

Suggested Readings

Chang, J.H. 1968. Climate and Agriculture, Aldine Pub. Chicago

Evans, L.T. 1963. Environmental Control and Plant Growth. Academic Press, New York.

Grace, John. 1983, Plant Atmospheric Relationships: Outline studies in Ecology, Chapman & Hall, New York, pp92.

Rose, C.W. 1966. Agricultural Physics, Pergamon, London

Sellers, W. 1967. Physical Climatology. The University of Chicago Press, Chicago.

6. Principles of modeling in agriculture biology (2+1)

Importance of primary data in modeling, system analysis, system input-output relationship, system classification, non-anticipative continuous and discrete *time* system, stationary and time variable systems, systems with and without memory distributed, Lumpod systems, block diagrams; flow charts, inverse of systems, statistical, Empirical and mathematical modeling and simulation: system objectives, modeling, collection of variables and parameters and classification into endogenous and exogenous variations, model fitting, debugging and validation of models. Process-based simulation modeling in agriculture and biology with special reference to crop growth and yield.

Practical

Modelling techniques, hands on with biological models, making of block diagrams, flow charts; model fitting, debugging and validation of models.

Suggested Readings

Gordan, G. 1992. System simulation. 2nd edn. Prentice Hall of India, New Delhi.

Kropff, M.J. and Vaan Laar, H.H. (ed.) 1993. Modelling Crop Wed Interactions. ISBN.

Mathews, R.B., Kropff, M.J., Bachelet, D. and Vaan Laar, H.H. (ed) 1993. Modelling the Impact of Climate Change on rice production in Asia. CAB International IRRI, Wallingford & Oxon. U.K.

Penning de Vries, F.W.T. and VanLaar, H.H. (ed). 1982. Simulation of plant growth and crop production. Wageningen Centre for Agril. Pub. & Documentation, Netherlands.

Zeigler, Bernard P. 1976. Theory of Modeling and Simulation. John Wiley and Sons, Inc, New York.

7. Remote sensing of environment (2+1)

Basic components of remote sensing; signals, sensors and sensing systems; active and passive remote sensing; characteristics of electromagnetic radiation's and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions; imaging and non-imaging systems, farming and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance; data acquisition systems; data processing; data storage and dissemination; digital image processing and information interpretation; Introduction to Geographic Information System and Geographic Positioning Systems. Remote sensing techniques in environment; monitoring and study of land surface processes- atmospheric pollution monitoring, ground water pollution monitoring, flood and drought mapping, assessment of land degradation- soil erosion, reservoir sedimentation, desertification, salinization, de- and re- forestation, shifting cultivation, and forest fires; remote sensing for forest mapping, geological mapping, snow, glacier and ice cover inventory; remote sensing in weather forecasting, temperature and precipitation estimates.

Practical

Acquisition of maps; familiarization of remote sensing imagery; Use of spectro-radiometer; working out spectral indices over a crop under different management; crop stress detection; use of infrared thermometer for stress detection; image analysis using ARCINFO / EASYPACE / IDRISI; crop discrimination; supervised classification using ground truth; Geographic Information System (GIS) application- ACRVIEW, SPANS; Use of Geographic Positioning System (GPS) in agriculture.

Suggested Readings

Colwell, R.N. (Ed) Colwell Roberl N. Manual of Remote Sensing Vol. I& II, Am Soc. Photogrammetry, Virginia.

Curan, P.J. Principles of Remote Sensing, ELBS/Longman.

Jain, A.K, 1989 Fundamentals of Digital Image Processing, Prentice Hall of India, Saddle river, NJ.

Kamat, D.S and Sinha, S.K Eds. Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June22-23, 1984, ICAR & ISRO.

Lillesand, T.M and Kiffer, R.W. 1999. Remote Sensing and image interpretation, 4th ed. John Wiley & son., Inc, New York.

Majumdar, K.L et.al., 1983. Selection of spectral bands and their widths for the Indian Remote Sensing satellite (IRS). RSP-1P/TN03/83, Space Applications Centre, Ahmedabad-380 053.

Suggested Readings

Chang, J.H. 1968. Climate and Agriculture, Aldine Pub. Chicago

Evans, L.T. 1963. Environmental Control and Plant Growth. Academic Press, New York.

Grace, John. 1983, Plant Atmospheric Relationships: Outline studies in Ecology, Chapman & Hall, New York, pp92.

Rose, C.W. 1966. Agricultural Physics, Pergamon, London

Sellers, W. 1967. Physical Climatology. The University of Chicago Press, Chicago.

6. Principles of modeling in agriculture biology **(2+1)**

Importance of primary data in modeling, system analysis, system input-output relationship, system classification, non-anticipative continuous and discrete time system, stationary and time variable systems, systems with and without memory distributed, Lumpod systems, block diagrams; flow charts, inverse of systems, statistical, Empirical and mathematical modeling and simulation: system objectives, modeling, collection of variables and parameters and classification into endogenous and exogenous variations, model fitting, debugging and validation of models. Process-based simulation modeling in agriculture and biology with special reference to crop growth and yield.

Practical

Modelling techniques, hands on with biological models, making of block diagrams, flow charts; model fitting, debugging and validation of models.

Suggested Readings

Gordan, G. 1992. System simulation. 2nd edn. Prentice Hall of India, New Delhi.

Kropff, M.J. and Vaan Laar, H.H. (ed.) 1993. Modelling Crop Wed Interactions. ISBN.

Mathews, R.B., Kropff, M.J., Bachelet, D. and Vaan Laar, H.H. (ed) 1993. Modelling the Impact of Climate Change on rice production in Asia. CAB International IRRI, Wallingford & Oxon. U.K.

Penning de Vries, F.W.T. and VanLaar, H.H. (ed). 1982. Simulation of plant growth and crop production. Wageningen Centre for Agril. Pub. & Documentation, Netherlands.

Zeigler, Bernard P. 1976. Theory of Modeling and Simulation. John Wiley and Sons, Inc, New York.

7. Remote sensing of environment (2+1)

Basic components of remote sensing; signals, sensors and sensing systems; active and passive remote sensing; characteristics of electromagnetic radiation's and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions; imaging and non-imaging systems, farming and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance; data acquisition systems; data processing; data storage and dissemination; digital image processing and information interpretation; Introduction to Geographic Information System and Geographic Positioning Systems. Remote sensing techniques in environment; monitoring and study of land surface processes- atmospheric pollution monitoring, ground water pollution monitoring, flood and drought mapping, assessment of land degradation- soil erosion, reservoir sedimentation, desertification, salinization, de- and re- forestation, shifting cultivation, and forest fires; remote sensing for forest mapping, geological mapping, snow, glacier and ice cover inventory; remote sensing in weather forecasting, temperature and precipitation estimates.

Practical

Acquisition of maps; familiarization of remote sensing imagery; Use of spectro-radiometer; working out spectral indices over a crop under different management; crop stress detection; use of infrared thermometer for stress detection; image analysis using ARCINFO / EASYPACE / IDRISI; crop discrimination; supervised classification using ground truth; Geographic Information System (GIS) application- ACRVIEW, SPANS; Use of Geographic Positioning System (GPS) in agriculture.

Suggested **Readings**

Colwell, R.N. (Ed) Colwell Roberl N. Manual of Remote Sensing Vol. I& II, Am Soc. Photogrammetry, Virginia.

Curan, P.J. Principles of Remote Sensing, ELBS/Longman.

Jain, A.K, 1989 Fundamentals of Digital Image Processing, Prentice Hall of India, Saddle river, NJ.

Kamat, D.S and Sinha, S.K Eds. Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June22-23, 1984, ICAR & ISRO.

Lillesand, T.M and Kiffer, R.W. 1999. Remote Sensing and image interpretation, 4th ed. John Wiley & son., Inc, New York.

Majumdar, K.L et.al., 1983. Selection of spectral bands and their widths for the Indian Remote Sensing satellite (IRS). RSP-1P/TN03/83, Space Applications Centre, Ahmedabad-380 053.

Sabins, F.F. 1997. Remote Sensing-Principles and Interpretation, 3rd ed. WH Freeman and Co., New York.

Schowengerdt, R.A. 1997. Remote Sensing, Models and Methods for Image Processing, 2nd Ed. Academic Press, New York.

8. Techniques of biophysics (2+1)

Isolation and purification of biological macromolecules and organnels; sedimentation; ultra-centrifugation; electrophoresis; electrobiphosis; chromatography; amino acid and nucleotide sequence analysis; diffusion; osmometry; viscometry; conductometry; dielectrometry; polarography; microcalorimetry; microscopy; polarized light microscopy; phase contrast microscopy; interference microscopy; electron microscopy; scanning electron microscopy; atomic force microscopy; light scattering, electron scattering, neutron scattering; optical rotatory dispersion, circular dicroism; Elements of spectroscopy, spectrophotometer, UV, visible, IR, Laser, EPR, NMR and Mossebauer spectroscopy principles.

Practical

In general, practical would be devised and set up by the instructors depending upon the equipments / instruments available in respective laboratories. However, some of the suggested practicals are: Sample component separation by centrifugation and sedimentation; electrophoresis; chromatography- liquid / paper; optical rotation by sugars using polarimeter; morphological observation of microscopic specimens using red, green and blue light illumination under light optical microscope and specific stains for enhancing contrast; plotting absorption / transmittance curves of coloured solutions with changes in wave lengths using spectrophotometer / photometer covering, visible, near ultraviolet and infrared spectral regions.

Suggested Readings

Birnie, G.D and Rickwood, R. 1978. Centrifugal separations in molecular and cell biology, Butterworths, London.

Cambell, G.S. 1997. An Introduction to Environmental Biophysics, Springer Verlag, Berlin.

Casey, E.J. 1962. Biophysics, Concepts and Mechanisms, Van Nostrand Reinhold Co.

Elsasser, W.M. 1958. The Physical Foundations of Biology, An analytical study, Pergamon Press, London.

Glick, D. Ed. 1967. Methods of Biochemical Analysis, vol. 15, Interscience, New York.

Hoppe, W, Lohmann, W, Mark, H, and Hubert, Z, 1983, Biophysics, Springer Verlag, Berlin.

Narayanan, P. 1998. Essentials of Biophysics, New Age International Publishing Co.Pvt. New Delhi.

Neuhoff, V. 1973. Molecular Biology, Biochemistry and Biophysics, vol. 14, p.205. London; Chapman and Hall: Berlin, Heidelberg and New York; Spriknger-Verlag

Pain, R.H and Smith, B.J, Eds. 1975. New Techniques in Biophysics and Cell Biology, Wiley, London.

Rashevsky, N, 1960, Mathematical Biophysics, Physico-Mathematical Foundations of Biology, Vol.2, Dover Publications, New York.

9. Nuclear techniques in agriculture and biology (2+1)

Structure of atom; atomic nucleus- its constituents, structure and stability, nuclear forces and energetics; mass formula; radio activity-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 radio nuclides; radio active equilibria (secular and transient); units of radio activity; interactions of nuclear radiations with matter; detection and measurement of nuclear radiations; Geiger-Muller, solid and liquid scintillation counters, nuclear emulsions; nuclear reactors-fission, fusion and breeder reactors; particle accelerators; detection and measurement of stable isotopes; concepts of isotope tracer methodology, isotopes 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; low level radiation in agriculture and biology, radiation hormesis, radiation induced phenomena; food irradiation; radiation protection; radio active waste disposals.

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 analyser; neutron moisture meter; use of NMR spectrometer; seed irradiation with gamma rays; radiocarbon dating.

Suggested Readings

Arnikar, H.J. 1989. Isotopes in the Atomic Age, Wiley Eastern, Ltd, New Delhi.

Bhaskaran, S. Ghosh, S.K. and Sethi, G.R. 1973. Proceedings of the International Symposium on Use of Isotop'es and Radiation in Agriculture and Animal Husbandry Research, Nuclear Research Laboratory, Indian Agricultural Research Institute, New Delhi.

Broetjes, C. 1965. The use of Induced Mutations in Plant Breeding, Pergammon Press, pp 691.

Burcham, E. 1995. Nuclear Physics, ELBS/Longman pp.409.

Glasstone, Samuel, 1967, Source Book of Atomic Physics, Affiliated East West Press, New Delhi, pp 883.

Kapoor, S.S and Ramamurthy, V.S. 1986. Nuclear Radiation Detectors, Wiley Eastern Ltd, New Delhi, pp 236.

Pochin.E. 1983. Nuclear Radiation: Risks and Benefits, Clarendon Press, Oxford, pp 197.

Rajam, J.B. 2000. Atomic Physics, S Chand and Co, New Delhi, pp 1279.

Tiwari, P.N. 1985. Nuclear Techniques in Agriculture, Wiley Eastern, New Delhi.

Wolf, G. 1964. Isotopes in Biology, Academic Press, New York.

10. Mathematics in agriculture and biology (2+1)

Numbers: natural numbers; integers; rational and irrational numbers; real numbers; rounding and significant digits of numbers; powers, roots and logarithms of numbers; systems of representation of numbers; rules of the game with the numbers; applications.

Sets: sets and their representations; finite and infinite sets; null sets; universal sets; elements of the set; subsets; complementary set; union and intersection of the sets; Boolean algebra- the rules of the game with the sets; Venn diagram; applications.

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; functions of complex variables; graphical experimental function; algebraic equations and their solutions in simple cases; applications.

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

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

Ordinary differential equation: classification; solution of linear differential equations; applications.

Partial differential equations: classification; applications.

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.

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.

Probability: Probability and probability distributions; applications

Statistics: univariate statistics- mean, standard deviation, variance, coefficient of variation; multivariate statistics- correlation, regression, covariance, applications.

Practical

Use of simple log and semi-log graph papers; use of logarithms and logrithmic tables; plotting linear and log graph; trignometric functions and relations; data representation as pie, bar and histograms; Statistical data analysis-averages, standard deviations, simple correlation coefficient.

Suggested Readings

Crank, J., Martin, H.G. and Melluish, D.M. 1980. Mathematics for Biological Sciences, Oxford University Press.

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

Vashistha, A.R. 1991. Modern Algebra, Krishna Prakashan Mandir, Meerut

Panse, V.G and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Research, 4th edn. ICAR, New Delhi.

Ray, M and Sharma, H.S. 1970. Mathematical Statistics, Ram Prasad and Sons, Agra

Scheild, Francis. 1983. Theory and Problems of Numerical Analysis, McGraw Hill.

3. AGRICULTURAL METEOROLOGY

A. Major

A.1	**Core Courses**	**12 credits**
	1. Fundamentals of meteorology	2+1
	2. Fundamentals of climatology	3+0
	3. Micrometeorology	2+1
	4. Agrometeorological Instrumentation	1+2
	Seminar	**0+1 credit**
A.2	**Optional Courses**	**8 credits**
	1. Evapotranspiration	2+1
	2. Agroclimatic analysis	2+2
	3. Crop weather models	1+2
	4. Water budgeting and drought meteorology	2+1
	5. Applied agrometeorology	3+0
	6. Weather and agriculture	2+1
	7. Hydrometeorology	2+1
	8. Weather modification	2+0
	9. Principles of Remote Sensing and its applications in agriculture	2+1
B.	**Supporting courses**	**14 credits**
	To be decided by the Student's Advisory Committee	
		Total 35 credits

A.1 Core Courses

1. Fundamentals of meteorology (2+1)

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

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. 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. 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. Weather charts, forecasting methods- short, medium and long range forecasting techniques, numerical weather prediction. EL Nino and Southern oscillations. Instruments for measurement of meteorological elements. Agromet observatory.

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.

Suggested Readings

Byers, H.R. 1959. General Meteorology. McGraw Hill, Inc., New York.

Ghadekar, A.E. 1991. Meteorology. Agromet Publishers, Nagpur.

Petterson, S. 1958. Introduction to Meteorology. McGraw Hill, Inc., New York.

Trewartha Glenn T. 1954. An Introduction to Climate, McGraw Hill, Inc., New York, pp.395.

1. Fundamentals of climatology **(3+0)**

Weather and climate: Climatological elements and their seasonal distribution over latitudes. Climatic classificatioin: Koppen, Thornthwaite, Hargreaves and Troll's systems, humid and dry climates. Continental, monsoonal, maritime and desert cli-

mates. Agroclimatic indices, agroclimatic zones; different agroecological zones for India. Climatology of India: Monsoons, length of day, temperature, rainfall and its variability, atmospheric and soil drought. Arid and semi-arid regions. Frequencies of disastrous weather events in the different regions, Climatological factors and their effect on crop growth and yield. Climatic change and its causes, global warming, Bioclimatology: Heat balance of animals, body temperature, inputs.

Suggested Readings

Haurwitz, B. and Austin, J.M. 1944. Climatology. McGraw Hill, Inc., New York, pp.410.

ICRISAT Climatic classification - A consultants meeting. 1980. ICRISAT-Hyderabad, India, p.153.

Lal, D.S., 1989. Climatology. Chaitanya Publishing Home, Allahabad, p.420.

Petterson, S., 1958. Introduction to meteorology. McGraw Hill. Inc. New York, pp.327.

Trewartha, Glenn T. 1954. An Introduction of Climate. McGraw Hill, New York, pp.395.

3. Micrometeorology (2+1)

Properties of atmosphere near the earth's surface. 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, variations in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth. 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--leaftemperature and its biological effects. Heat transfer near and within the ground. Influence of topography on microclimate. Shelter belts and wind breaks, micro climate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates. Instruments and measuring techniques in micrometeorology. Effects of ambient weather conditions on growth, development and yield of crops. Crop-weather relations, statistical regression equations and crop growth models.

Practical

Measurement of global radiation and diffuse radiation; Measurement of albedo over natural surfaces and cropped surfaces; Net radiation measurement at different levels; PAR distribution in plant canopoes and interception; Wind, temperature and humidity profiles in (a)short crops and (b) tall crops; Energy balance over crops and LAI and biomass estimation.

Suggested readings

Chang, J.H. 1968. Climate and Agriculture, Aldine Publishing Co.,Chicago.

Evans, L.T. 1963. Environmental Control and Plant Growth, Academic Press, New York.

Gates, D.M. 1968, Energy Exchange in the Biosphere, UNESCO, Paris.

Grace, John 1983. Plant Atmospheric Relationships: Outline studies in Ecology, Chapman & Hall, New York, pp92.

Munn, R.E, 1970. Biometeorological Methods, Academic Press, New York.

Rose, C.W. 1996. Agricultural Physics, Pergamon, London

Sellers, W. 1967. Physical Climatology. The University of Chicago Press, Chicago.

4. Agrometeorological instrumentation (1+2)

Fundamentals of measurement techniques, theory and working principles of barometers, thermometers, thermographs, psychrometers, hair hygrometer, thermohygrograph, rainguage, self recording rain gauge, duvdevani dew gauges, lysimeters, open pan evaporimeters, anemometer, windvane, anemograph, soil thermometers, soil heat flux plates, instruments for measuring soil moisture, sunshine recorder, albedometer; photometer, spectro-radiometer, quantum radiation sensors,, pressure bomb apparatus, porometer, photosynthesis system, infra-red thermometer.

Practical

Working with the above instruments in the meteorological observatory, taking observations of relevant parameters, computation interpretation of the data.

Suggested Readings

Byers, H.R. 1959.General Meteorology. McGrow Hill BookCo. Inc., New York.

Middleton. W.E. and Spilhaws. A.F. 1962. Meteorological Department. Univ. of Toronto. Press. Canada.

Tanner, C.B. 1973. Basic Instrumentation and Measurements for Plant Environment and Micrometeology. Univ. of Wisconzin, Madisan, Wisconsin, USA.

NCERT. 1985.Agrometeorology- A Practice Manual, NCERT Pub.

A.2 **Optional Courses**

1. Evapotranspiration **(2+1)**

Basic laws of radiation, Radiation interaction with plant environment, Energy balance in atmosphere, crop canopy. The atmosphere near the ground. Laminar and turbulent flows. Wind profile near the ground, 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- modified techniques. Influence of microclimatic, plant, soil and cultural factors. Techniques of lysimetry in measuring actual evapotranspiration. Yield functions, water use efficiency and scheduling of irrigation based on evapotranspiration. Radiation instruments. Advanced techniques for measurement of radiation and energy balance. Computation of K_c values and their use.

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 and Measurement of wind and temperature profiles near the ground.

Suggested Readings

Chang, J.H. 1968. Climate and Agriculture, Aldine Pub. Chicago

Evans, L.T. 1963. Environmental Control and Plant Growth. Academic Press, New York.

Grace, John. 1983, Plant Atmospheric Relationships: Outline studies in Ecology, Chapman & Hall, New York, pp92.

Rose, C.W. 1966. Agricultural Physics, Pugaman London

Sellers, W. 1967. Physical Climatology. The University of Chicago Press, Chicago.

2. Agroclimatic analysis (2+2)

Review of Agroclimatic methods, characteristics of agroclimatic elements; Sampling of atmosphere: temporal and spatial considerations: micro-meso- and macro climates. Network spacing. Numerical characterization of climatic features. Crop response to climate, time lags, time and distance constants, hysteresis effect; influence of climate on stress-response relations. 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.

Instrumentation and sampling problems--design of agrometeorological experiments. Data processing techniques in agroclimatology—synoptic, numerical and graphical techniques, spatial analysis of weather systems and charts.

Modelling techniques of crop weather relations. Methods of forecasting crop yields, pests and disease development, using climatic inputs.

Practical

Calculation of Continentality factors, PET by Thornthwaite method; Computation of Climatic Water balance and its components. Climatic indices and climograms; Degree days, Photothermal, Phenthermal and other indices, heat units; Heat use efficiency of crops, Biomass, crop growth rates; Analysis of Thermogram, Hygrogram, Hyetogram, sunshine cards etc; Preparation and analysis of isobar chart, isothermal and isohyetal charts. Stream lines and wind roses and Statistical analysis of climatic data.

Suggested Readings

Conrad, V. and L. W. Pollak. 1950. Methods in Climatology, Harvard University Press.

IMD/WHO. 1998. Users Requirements for Agrometeorological Services, IMD pp.336.

Munn, R.E. 1970. Biometeorological Methods. Academic Press. New York and London.

Thom,H.C.S. 1971. Some Methods of Climatological Analysis. W.M.O. Technical Note No. 81, W.M.O.Geneva.

3. Crop weather models **(1+2)**

Principles of crop production, Evaluation of crop responses to weather elements, Impact of natural and induced variability of climate on crop production. 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, forecasting of pests and diseases.

Practical

Working with statistical and simulation models, Plantgro, Ceres models, Brassica, Rescap etc.

Suggested Readings

DeWit, C.T.,Brouwer, R. and de Vries, F.W.T. P. 1970. The simulation of photosynthetic systems. pp.7-70. In. Prediction: and measurement of photosynthetic activity. Proc. Int. Biological Programe Plant Physiology Tech. Meeting Trebon. PUDOC, Wageningen, The Netherlands.

Duncan, W.G. 1973. SIMAI- A model simulating growth and yield in corn. In. the application of systems methods to crop production (Ed. D.N. Baker). Mississippi State Univ. Mississipi.

Frere, M. and Popav, *G.* 1979. Agrometeorological Crop Monitoring and Forecasting. F.A.O. Rome.

Hankes, R.J. 1974. Mode for Predicting Plant Yield as Influenced by Water Use. Agron. J. 66: 660-665.

Keulen, H. Van. And Seligman, N.G. 1986. Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop. Simulation monographs. PUDOC. Wageningen.

4. Water budgeting and drought meteorology (2+1)

Water budgeting in climatic studies, Soil moisture budget models of Thornthwaite and Mather, and Baier. Linear models, log and exponential models of soil moisture decay. Water and yield relationships, consumptive use and water use, dry matter production and water use efficiency. Concept of drought and its meaning, types and kinds of drought, permanent, seasonal droughts and contingent droughts, Atmospheric, *agricultural and* hydrological drought, use of rainfall analysis in drought. Water balance concept in drought studies, frequency and intensity droughts, mild, moderate and severe droughts. Spread of drought, MAI and its probability. Drought prediction and Remote sensing in drought monitoring.

Impact of climatic water budgeting parameters on crop planning and agricultural products.

Practical

Drought classification using seasonal and annual rainfall, Monthly and weekly water balance, Aridity and Humidity indices, drought classification by water deficiency and Aridity index, MAI and its probability, Short term droughts, Duration and intensity of dry spells, evaluation of different kinds of drought.

Agricultural drought, categorization of agricultural droughts, Principles and practices for agricultural drought management- short term and long term approaches.

Suggested Readings

Baier, W. and Robertson, G.W. 1966. A new versatile soil moisture budget., Can. J. Plant Sci. 46: 299-315.

Palmer, W.C., 1964. Meteorological Drought, Res. Paper No. 45. Weather Bureau.

Palmer, W.C. 1968. Keeping track of crop moisture conditions Nationwide: the new crop moisture index. Weatherwise 21, 156-161.

Subrahmanyam, V.P. 1967. Incidence and spread of continental drought. WMD/IHD Rept. No.2. World Meteorol Organization, Geneva.

Thorlnthwaite, C.W. and Mather, J.R. 1955. The Water Balance, Publications in Climatology. Laboratory of Climatology, Centerton (NJ) Vol.8, No. 1.

5. Applied **agrometeorology** (3+0)

Phenology and seasonal changes of weather conditions. Thermoperiodism, photoperiodism, heat unit concept and its applications. Climatic water budgeting technique and its application in evaluation of moisture availability periods within crop growing season, planning of multiple cropping pattern for different soil-climatic zones of India based on above techniques. Influence of agrometeorological factors on incidence of pests and diseases- effects on timing and effectiveness of control measure on herbicides, nematode population, seed rate Weather forecasting for agriculture. General forecasting- medium range, short range and seasonal forecasting for agricultural purposes. Special weather forecasts for frosts, hail, insects, pests and diseases, droughts, high winds, heat waves etc. Crop protection from weather hazards. Protection from frost, forest fire, drought and floods, wind breaks and shelter belts.

Suggested Readings

Gadvian J. 1977. Crop Micro Meteorology and Simulation Study, PUDOC. Wagenedigan, pp.249.

Grace, J. 1977. Plant Atmolspheric Relationships: Outline studies in ecology, clapman and Hall New York.

Mavi, H.S. Introduction to Agrometeorology. Oxford IBH, Publishing Co. New Delhi. Jhon Grace 1983. Plant atmospheric relationship. Chepman and Hall, New York.

Munn, R.E., 1970. Biometeorological Methods. Meteorological services of Canada Tononto, Canada.

6. Weather and agriculture (2+1)

Climate and crop production, weather factors affecting plant growth. Cardinal weather parameters for different crops Effect of weather elements on crop production, Measurement of weather parameters. weather and crop growth relations, weather and incidence of pests and diseases. Crop weather calenders. Use of weather forecasting in agriculture. Weather based Agro advisories.

Agricultural seasons and their significance on crop production. Important crops of each season- specific to region. Weather abnormalities and weather hazards their effects and methods of overcoming.

Practical

Preparation of crop weather calendars; Weather and pest relations in different cropping system; Computation of parameters for weather forecasting; Agroadvisories.

Suggested Readings

Chang Jen Hn. 1968. Climate and Agriculture Aldine Publishing Co., Chicago.

Critchfield, H.J. 1975. General climatology, Prentice Hall, London.

Geiger, R. 1966. The Climate Near the Ground. Horwend University Press, Cambridge.

Mavi, H.S. Introduction to Agrometeorology. Oxford IBH Publishing Company, New Delhi.

Sellers, W. 1965. Physical Climatology, University of Chicago Press, Chicago.

7. Hydrometeorology (2+1)

Hydrologic cycle and its modifications. Rainfall and its interception by plants and crops. Measurement of runoff, infiltration, moisture retention of soil, percolation, evaporation, evapotranspiration and its importance to agriculturists, irrigation engineers and flood forecasting personnel. Water holding capacity of soils, available water cultural practices on soil moisture in relation to different phases of crop growth. Evaporation from snow, lakes, reservoirs and crops. Drought and its effect on water balance. Climatic water budgeting and its applications.

Practical

Compilation of water balance for selected stations; Estimation of water surplus and runoff; Visit to Dam areas and assessing hydrometeorological problems.

8. Weather modification **(2+0)**

Historical review of weather modification, evolution of atmospheric composition, green house effect; present status of weather modification for agriculture, theories of weather modification, scientific advances in cloud seeding for rainfall, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electrical behaviour of clouds, modification of frost intensity, shelter belts and wind breaks, mulches and antitranspirants, protection of plants against climatic hazards- air and water pollution. Field trips to sites where weather modification has been introduced.

Suggested Readings

Critchfield, M.J. 1975. General Climatology, Prentice Hall, London.

Riehl, H. 1978. Introduction to the Atmosphere. Mc Graw Hill, New York.

Sutchffe, R.C. 1966. Weather and Climate, Weidanfeed and Nicolson.

9. Principles of remote sensing and its applications in agriculture (2+1)

Basic components of remote sensing: signals, sensors and sensing systems; active and passive remote sensing; characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions; imaging and non imaging systems; framing and scanning systems; resolution of sensors; sensors platforms, their launching and maintenance; data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction; microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

Digital techniques for crop discrimination and identification; crop stress detection-soil moisture assessment, inventory of ground water & satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation; 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; demonstrations of case studies; hands on training.

Suggested readings

Colwell, R.N.(editor). Manual of Remote Sensing -Vol. I& II, Am Soc. Photogrammetry, Virginia.

Curan, P.J. Principles of Remote Sensing, ELBS/Longman.

Jain, A.K. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India, Saddle river, NJ.

Kamat, D.S and Sinha, S.K (eds) 1984. Proceedings of the Seminar on Crop Growth Condition and Remote Sensing, June 22-23, ICAR & ISRO.

Lillesand T.M and Kiffer, R. W. Remote Sensing and image interpretation, John Wiley & son., Inc, New York.

Majumdar, K.L et.al, 1983. Selection of spectral bands and their widths for the Indian Remote Sensing satellite (IRS). RSP-1P/TN03/83, Space Applications Centre, Ahmedabad-380 053.

Sabins, F.F. 1997. Remote Sensing-Principles and Interpretation, 3rd ed. WH Freeman and Co.

Schowengerdt, R. A. 1997. Remote Sensing, Models and Methods for Image Processing, 2nd edn. Academic Press, London

4. SOIL SCIENCE & AGRICULTURAL CHEMISTRY

A. Major

A.1	**Core Courses**	**12 credits**
	1. Soil mineralogy, genesis and classification	2+1
	2. Soil chemistry	2+1
	3. Soil biology and biochemistry	2+1
	4. Soil physics	2+1
	Seminar	**0+1 credit**
A.2	**Optional courses**	**8 credits**
	1. Soil fertility and plant nutrition	2+1
	2. Soil technology	2+1
	3. Soil survey and land use planning	2+1
	4. Soil-water-plant relationships	2+1
	5. Manures and fertilizers	2+1
	6. Soil pollution	2+1
	7. Land degradation and restoration	2+0
	8. System approach in soil research	2+0
	9. Instrumental techniques in soil and plant analysis	1+2
B.	**Supporting courses**	**14 credits**
	To be decided by the Student's Advisory Committee	
		Total 35 credits

A.1. Core Courses

1. Soil mineralogy, genesis and classification (2+1)

Structural chemistry-ionic radii, coordination theory, Pauling's rules, isomorphism, solid solution and polymorphism; Classification, structure, characteristics, distribution, origin and alteration of soil minerals; Genesis and transformation of clay minerals; Non-crystalline components of soils; History and systems of soil classification, diagnostic horizons of soils of different orders; Taxonomy of soils of India; Soil micromorphology.

Practical

Study of crystal systems and crystal structures of soil minerals. Separation of light and heavy minerals. Mineral identification by conventional and instrumental methods. Preparation and study of thin sections, surface area determination. Study of soil profile.

Suggested Readings

Buol, S.W.; Hde, F.D. and McChackeni, R.J. 1995. Soil Genesis and Classification. East West Press, New Delhi, pp.360.

Grim, R.E. 1968. Clay Mineralogy. McGraw Hill, New York, pp.384.

Sehgal, J. 1986. Introductory Pedology: Concepts and Applications. Kalyani, New Delhi, pp.485.

USDA 1998. Keys to Soil Taxonomy (8th edn). Oxford and IBH, New Delhi, pp.326.

Wade, F.A. and Mattox, R.B. Elements of Crystallography and Mineralogy. Oxford and IBH, New Delhi, pp.326.

Wade, F.A. and Mattox, R.,B. Elements of Crystallography and mineralogy. Oxford and IBH Publishing Co. New Delhi, pp.331.

Wilding, L.P., Smeck, N.E. and Holl,G.F. (ed.). 1983. Pedogenesis and soil taxonomy. I Concept and Interaction. Elsevier Science Pub. New York, pp.303.

Wilding, L.P., Smeck, N.E. and Holl,G.F. 1983. Pedogenesis and Soil taxonomy: II. The Soil Orders. Elsevier Science Pub., New York, pp.410.

2. Soil chemistry (2+1)

Concepts of chemical equilibria in soils; Soil colloids. Solubility relationship of important nutrients and aluminosilicates in soils, salt dissolution and precipitation; Thermodynamics and kinetics of chemical reactions; Organic matter and characterization clay-organic matter interaction, ion retention-mechanism and chemical and empiri-

cal relationships; Surface chemistry and nutrient dynamics; Chemical and electrochemical properties of submerged soils; Chemistry of acid and salt affected soils and their reclamation.

Practical

Analysis of equilibrium soil solution for E_h, pH, EC and partial pressure of CO_2. Determination of ion activity. Common ion effects on solubility. Exchange reactions of Na, K, Ca, Mg in soils. Characterization of acid and salt affected soils. Lime and gypsum requirement.

Suggested Readings

Bear, RE. 1964. Chemistry of Soil. Oxford and IBH Pub. Co., New Delhi, pp.515.

Fried, M. and Broeshart, H. 1967. Soil Plant System, Academic Press, New York, pp.358.

Greenland, D.J. and Hayes, M.H.B. 1978. Chemistry of Soil Constituents. John Wiley and Sons. pp.714.

Stevenson, F.J. 1982. Humus Chemistry. John Wiley, New York, pp.443.

Van Olphan, H. 1977. Introduction to clay colloid chemistry. John Wiley and Sons, New York, pp.318.

3. Soil biology and biochemistry (2+1)

Soil biota, soil microbial ecology- types of organisms in different soils, soil microbial biomass; Microbial interactions; Microbiology and Biochemistry of root soil interface; Phyllosphere; Biofertilizers; Soil enzymes- activities and importance; Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in the soil; Biochemical composition and biodegradation of soil organic matter and crop residues; Organic wastes and their use for production of biogas and manures; Biotic factors in soil development.

Practical

Determination of microbial population; Microbial biomass; Activities of different enzymes in soil; Biochemical constituents of organic residues- cellulose, hemicellulose, lignin and C:N ratio; Estimation of decomposition rates of different organic residues; Mineralization and immobilization turn-over of nitrogen.

Suggested Readings

Alexander, M. 1977. Introduction to Soil Microbiology. John Wiley, New York, pp.467.

Burges, A. and Raw, F. 1967. Soil Biology. Academic Press, New York, pp.532.

McLaren, A.D. and Peterson, G.H. 1967. Soil Biochemistry. Vol.11 Marcel Dekkar Pub., New York, pp.509.

Paul, E.A. and Ladd, J.N. 1981. Soil Biochemistry Vol.V Marcel Dekkar, N. Y. pp.480.

Reddy, M.V. (editor). 1995. Soil Organisms and Litter Decomposition in the Tropics. Oxford & IBH, New Delhi pp.274.

Russel, R.S. 1977. Plant root system: Their function and interaction with the soil. ELBS & McGraw Hill, New York pp.298.

Stotzky, G. and Bollag, J.M. 1993. Soil Biochemistry Vol. VIII. Marcel Dekkar, New York. pp.418.

Wild, A. 1993. Soil and the Environment. An introduction Cambridge Univ. Press pp.287.

4. Soil physics (2+1)

Soil water behaviour- infiltration, redistribution, retention and movement; Soil water potential, soil water balance, soil water management practices; Spatial variability in soils; Soil physical environment and soil fertility relationship; Consistence, swelling, shrinking, dispersion and workability of soils. Soil compaction-processes, factors, isograms; Soil texture; Soil structure- genesis, evaluation and management. Puddling and its effects- soil physical behaviour; Soil temperature- thermal properties, variations and modifications; Soil air- characterization and measurement in relation to plant growth; Alleviation of soil physical constraints for crop production.

Practical

Atterberg limits, wet aggregates, modulus of rupture, coefficient of linear shrinkage, proctor moisture content, bulk density-soil strength relationships, pore size distribution, oxygen-diffusion rate and thermal conductivity; Measurement of soil temperature using thermisters and thermocouples; Determination of infiltration rates. Soil moisturecharacteristiccurves.

Suggested Readings

Baver, L.D., Gardner, W.H. and Gardna, W.R. 1972. Soil Physics. John Wiley, New York.

Oswal, M.C. 1994. Soil Physics- Oxford IBH, New Delhi.

Hanks and Ascheroft. 1980. Applied Soil Physics. Springer-Verlag, Berlin.

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

Hillel, D. 1982. Introduction to Soil Physics. Academic Press, New York.

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

Khanke, H. 1968. Soil Physics. McGraw Hill, New York.

Kirkham, D. and Powers, W.L. 1972. Advanced Soil Physics. Wiley Interscience.

A.2 Optional courses

1. Soil fertility and plant nutrition (2+1)

Forms, availability, mobility and losses of macro and micronutrients in soils; Nutrient deficiencies and toxicities- recent diagnostic techniques and ameliorative measures; Nutrients and nutrient-water interactions; Balanced use of nutrients. Integrated plant nutrient supply and management; Nutrient uptake mechanisms; Nutrient release and carry-over effects; Quantity- intensity relationships; Soil fertility evaluation; Soil test crop response correlations and response functions.

Practical

Laboratory and greenhouse experiments for evaluation of indices of nutrient availability and their critical values in soils and plants; Determination of different pools of macro and micronutrients; Quantity-intensity relations of P and K.

Suggested Readings

Barber, S.A. 1984. Soil Nutrient Bioavailability. John Wiley, New York pp.389.

Cooke,G.W. 1967. The Control of Soil Fertility. Crossby Lockwood and Sons, London, pp.526.

Epstein, E. 1978. Mineral Nutrition of Plants- Principles and Perspectives. Wiley Eastern, New Delhi, pp.412.

Lindsay, W.L. 1979. Chemical Equilibria in Soils. John Wiley; New York, pp.449.

Mengel, K. and Kirkby, E.A. 1987. Principles of Plant Nutrition. International Potash Institute, Swsitzerland, pp.687.

Mortvedt, J.J. Shuman, L.M., Cox, F.R. and Weich, R.M. (ed). 1991. Micronutrients in Agriculture. Soil Science Society of America, pp.760.

Prasad, R. and Power, J.F. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Lewis, Boca Ratoon, USA, pp.356.

Singh, Dhyan, Chhonkar, P.K. and Pandey, R.N. 1999. Soil Plant Water Analysis. A Methods Manual. Indian Agricultural Research Institute, New Delhi, pp. 160.

Tisdale, S.L, Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1990. Soil Fertility and Fertilizers (5th edn). Macmillan Pub. New York, pp.754.

Wild, A. (ed) 1988. Soil Conditions and Plant Growth (11th edn.) Longman, London, pp.991.

2. Soil technology **(2+1)**

Scope and introduction; Extent, distribution and chemistry of problem soils; management of acid and acid sulphate, saline, sodic and calcareous; Management principles of sandy, clayey, red and lateritic, and dryland soils; Soil-plant adjustment principles; Quality of irrigation water and management of saline water for irrigation.

Practical

Characterization of acid, acid sulphate, saline, sodic and calcareous soils; Lime requirement of acid soils; gypsum requirement of sodic soils; Quality aspects of irrigation water.

Suggested Readings

Bear, F.E. 1964.Chemistry of Soil, Oxford & IBH Pub. New Delhi 515.

Black, C.A. 1968. Soil Plant Relationships. John Wiley, New York, pp.792.

Tu Tram Rou. Physical Chemistry of Problem Soils.

Ghassemi, F., Jakeman, A.J. and Nix H.A. 1995. Salinization of Land and Water Resources, CAB International, Wallingford, U.K. 526.

3. Soil survey and land use planning (2+1)

Soil survey procedures; Remote sensing techniques including aerial photointerpretation; Cartography- principles and techniques for preparation of soil and other interpretative maps, processing of field sheets, compilation and abstraction of maps on different scales; Soil correlation; Criteria for classification at different levels in Soil Taxonomy; Soil quality assessment; Interpretation of soil resource information for agricultural and non- agricultural uses;. Land use planning concepts of benchmark soils for agrotechnology transfer in soils; Geographic information; Systems for resource inventorilization.

Practical

Study of soil profiles developed in different moisture and temperature regimes and

their classification; Study of landforms using remote sensing data. Soil survey of a project area using aerial photographs and preparation of soil survey report, Preparation of soil monoliths, Computer use in soil mapping.

Suggested Readings

Davidson, D.A. 1983. Soil and Land Use Planning. Longman; New York.

Dent, D and Yarg, A. 1987. Soil Survey and Land Evaluation. 2nd edn. George Allen Ltd.

FAO. 1989. Guidelines for Land Use Planning. FAO, Rome.

Ferro. 1990. Sustainable Land Use System Research. IBH and Oxford.

Lindgren David, T. 1988. Land Use Planning and Remote Sensing. Martines Nijhoff Pub, Netherlands.

Sehgal, J.L. 1986. Introductory Pedology- Concepts and Applications. Kalyani Pub., New Delhi.

USDA Staff. 1995. Soil Survey Manual. Scientific Pub., Jodhpur.

4. Soil-water-plant relationships (2+1)

Soil-plant-atmosphere continuum- pathways of water movement, variations in water potentials and fluxes. Solute transport in soils; Root growth in relation to soil physical environment. Modelling water uptake by plants at macro and micro levels. Evapotranspiration and growth relations. Models for water use, plant growth and yield in terms of water availability.

Practical

Evapotranspiration losses under different situations. Salt and water profile changes during infiltration. Measurement of canopy temperature, leaf diffusion resistance, xylem water potential. Determination of components of water balance in a cropped field.

Suggested Readings

Doorenbos, J. and Pruitt, W.O. 1975. Crop water requirements. FAO Irrigation and Drainage Paper 24. Rome, Italy.

Hillel, D. 1977. Soil and water: physical principles and processes. Academic Press. Inc. New York.

Richards, L.A. 1955. Retention and transmission of water in soil. Year Book of Agriculture. 14-151.

SCS, 1964. Soil- plant- water relationship. Soil Conservation Service Engineering Hand Book. USDA.

Slatyer, R.O. 1967. Plant- water relations, Academic Press, New York.

Turner, A.K., Willatt, ST., Wilson, J.H. and Jobling, G.A. 1984. Soil- water management. IDP, Canberra, Australia.

5. Manures and fertilizers (2+1)

Role of manures in sustainable agriculture; Rural, urban enriched composts- preparation, preservation and mechanisms of their decomposition under different moisture regimes. Fertilizer production, future projections and consumption in India. Production, characteristics and use of different fertilizers. Fertilizer interaction in soils. Use of low grade phosphate rocks on different types of soils. Recent developments in secondary and micronutrient fertilization; factors affecting fertilizer use efficiency. Integrated nutrient management for sustainable agriculture. Long-term effects of manures and fertilizers on soil productivity; quality control of fertilizers and Fertilizer Control Order.

Practical

Determination of moisture, nitrogen, phosphorus and potassium in fertilizers as per FCO; Composting and analysis of composts for C:N, C:P and C:S ratios.

Suggested Readings

FAI. 1999. Fertilizer (Control) Order, 1985 and the Essential Commodities Act. 1955. FAI, New Delhi, pp.203.

Kanwar, J.S. (ed). 1976. Soil Fertility: Theory and Practice. ICAR, New Delhi pp.583.

Mortved, J.J. et al. Micronutrients in Agriculture. SSSA Madison pp.760.

Olsen, R.A. et al.(eds) 1981. Fertilizer Theory and Practice. ICAR, New Delhi pp.583.

Prasad, R. and Power, J.F. 1997. Soil Fertility Management for Sustainable Agriculture, CRC Lewis, Boca Raton, Florida, USA.

Tisdale,S.L. and Nelson, W.L. 1990. Soil fertility and fertilizers. McMillan Pub. Co. N.Y. pp.754.

Vogel, A.I. 1979. A text book of Quantitative Inorganic Analysis. ELBS London, pp.925.

6. Soil pollution (2+1)

Pollution problems and hazards. Nature and sources of pollutants-industrial, agricultural and municipal wastes, fertilizers, pesticides, radionucleotides, fossil fuels, acid rains, oil spills, etc. Soil sickness due to biological agents and toxins etc.; Heavy metals- toxicity, effects on nutrient availability and plant growth; Characterization and monitoring of pollutants; Air and water pollution as related to soil - nature of pollutants, sources and effect on plant growth; Pollution control; Soil as a sink for waste disposal. Remediation of contaminated soil and water.

Practical

Sampling of industrial effluents and municipal waste waters. Estimation of dissolved and suspended solids; Chemical oxygen demand (COD); biological oxygen demand (BOD), nitrate and ammoniacal nitrogen and phosphorus. Heavy metal analysis of contaminated soil and water; Air sampling and determination of particulate matter and oxides of sulphur.

Suggested Readings

Middlebrooks, E.J. 1971. Industrial Pollution Control Vol.1. Agro-Industries. John Wiley Interscience, New York.

Ross, S.M. 1994. Toxic Metals in Soil Plant Systems. John Wiley & Sons Chickester, U.K.

Vesilund, P.A. and Pierce, J.J. 1983. Environmental Pollution and Control. Ann Arbor Science Pub. In Mi. USA.

7. Land degradation and restoration **(2+0)**

Basic concepts. Types, factors (natural and anthropogenic) and processes of soil/ land degradation. Processes, causes and impact of land degradation, restoration and conservation techniques (soil-erosion control and salt- affected soils, mine-land reclamation, afforestation, organic byproducts, soil fauna and biodegradation). Role of GIS in monitoring, diagnosis and mapping land degradation. Policy considerations (incentives and legal measures). Global issues for twenty first century.

Suggested Readings

Biswas, T.D. and Narayanasamy, G. (Eds) 1996. Soil management in relation to land degradation and environment Bull. Indian Soc. Soil Sci. No. 17.

Doran, J.W. and Jones, A.J. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Inc., Madison, pp.410.

Greenland, D.J. and Szabolcs, I. 1994. Soil Resilience and Sustainable Land Use. CAB International Wallingford, U.K.

Lal, R., Blum, W.H., Vailentine, C. and Steward, B.A. 1997. Methods for Assessment of Soil Degradation. CRC Press. Boca Raton New York, pp.558.

Sehgal, J. and Abrol, I.P. 1994. Soil Degradation in India Status and Impact. Oxford & IB Publishing Co., New Delhi.

8. Systems approach in soil research (2+0)

Systems concept- its characteristics and significance in soil research. Methods in systems analysis- flow charts, mathematical models, components, interaction within and among the components. Analysis of systems using appropriate models, their validation and sensitivity analysis. System for maximizing soil productivity under different soil, water, nutrient and climatic conditions and cultural practices. Use of models for decision support system.

Suggested Readings

Friessel, M.J. and Reiniger, P. 1974. Simulation of accumulation and leaching in soils. Oxford & IBH Pub. New Delhi.

Hanks, J. and Richie, J.T. (eds) 1991. Modeling Plant & Soil System. Agronomy Bull. No. 31.Soil Science Soc. Of America, Madison.

Lipschutz, S. and Arthur, P. 1982. Schaum's outline of theory and problem of programming with Fortran by Seyman.McGraw Hill,Singapur pp.314.

9. Instrumental techniques in soil and plant analysis (1+2)

Principles of visible ultraviolet and infrared spectrophotometlry, atomic absorption, chromatographic techniques, potentiometry, conductometry emission and mass spectrometry. Ion selective electrodes; Tracer techniques in soil and plant research.

Practical

Rapid tissue tests; Determination of elemental composition of soils and plant using flame emission, atomic absorption, ultraviolet, visible and infrared spectrophotometers; Potentiometric and conductometric titrations; Chromatographic analysis; Use of radioisotopes in soil and plant analysis.

Suggested Readings

Alexeyev, V. 1979. Quantitative Analysis. MIR Publishers, Moscow. pp.519.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall of India, New Delhi pp.498.

Page, A. L., Miller, R.H. and Koery, D.R. 1982. Methods of Soil Chemical Analysis Part. II. SSSA & Am, Soc. Agron., Madison.

Tandon, HLS 1993. Methods of Analysis of Soils, Plants, Fertilisers and Waters. FDCO.Books, New Delhi. pp.143.

Singh, D., Chhonkar, P.K. and Pandey, R.N. 1999. Soil Plant Water Analysis- A methods manual, Indian Agril. Res. Inst., New Delhi & ICAR, pp.160.

Vogel, A.I. 1979. A Text book of Quantitative Inorganic Analysis, ELBS; London, pp.925.

Willard H.H., Merritt Jr. L.L.,Dean J.A. Settle,Jr. F.A. 1986. Instrumental method of analysis. C.B.S. Publishers, New Delhi-1.

Meeting of BSMA Committee on Physical Sciences held on 6th and 7th May, 1999 in the Division of Agronomy

LIST OF PARTICIPANTS

1. Dr S L Mehta, Deputy Director General (ICAR)
2. Dr N L Maurya, Asstt. Director General (Acdn.) (ICAR)
3. Dr Rajendra Prasad, Coordinator BSMA, Physical Sciences
4. Dr M S Bajwa, Dean, PG, PAU, Ludhiana
5. Dr D K Das, Ex-Head, Agril. Physics, IARI
6. Dr B C Panda, Ex-Head, Agril. Physics, IARI
7. Dr R S Narang, Ex-Professor of Agronomy, PAU, Ludhiana
8. Dr Banarsi Lal, Professor of Agronomy, GBPUAT, Pantnagar
9. Dr R C Gautam, Head, Divn. of Agronomy, IARI, New Delhi
10. Dr P K Chhonkar, Head, SS&AC Divn., IARI
11. Dr R P Arora, Head, Divn. of Agric. Physics, IARI
12. Dr K K M Nambiar, Professor, Divn. of SS&AC, IARI
13. Dr J Pandey, Principal Scientist, Divn. of Agronomy, IARI
14. Dr N T Yaduraju, Sr. Scientist, Divn. of Agronomy, IARI
15. Dr Surendra Singh, Sr. Scientist, Divn. of Agronomy, IARI
16. Dr Narainaswamy, Sr. Scientist, Divn. of SS&AC, IARI
17. Dr R K Rattan, Sr. Scientist, Divn. of SS&AC, IARI
18. Dr Anupam Varma, Dean, PG School, IARI (Chaired the Plenary Session)

Annexure II

BSMA (Physical Sciences) Workshop on Reconstruction of Post Graduate Courses at SAUs on April 6 & 7, 2000 at Division of Agronomy, IARI, New Delhi 110 012

LIST OF PARTICIPANTS

A. ICAR & IARI

1. Dr S L Mehta, Deputy Director General (ICAR)
2. Dr N L Maurya, Asstt. Director General (Acdn.) (ICAR)
3. Dr D G Diwakar, Principal Scientist (Edn.), ICAR, New Delhi
4. Dr Rajendra Prasad, ICAR National Professor, Division of Agronomy, IARI, New Delhi
5. Dr A K Singh, Project Director, WTC, IARI
6. Dr R C Gautam, Head, Divn. of Agronomy, IARI
7. Dr P K Chhonkar, Head, Divn. of SS&AC, IARI
8. Dr P N Takkar, former Director, IISR, Bhopal, Divn. of SS&AC, IARI
9. Dr D K Das, Ex-Head, Division of Agricultural Physics, IARI
10. Dr J Pandey, Professor, Divn. of Agronomy, IARI
11. Dr K K M Nambiar, Professor, Divn. of SS&AC, IARI
12. Dr A V Moharir, Professor, Divn. of Agric. Physics, IARI
13. Dr G Narayansamy, Sr. Scientist, Divn. of SS&AC, IARI
14. Dr R K Rattan, Sr. Scientist, Divn. of SS&AC, IARI
15. Dr CVS Shastri, Divn. of Agril. Physics, IARI
16. Dr I P S Ahlawat, Sr. Scientist, Divn. of Agronomy, IARI
17. Dr N T Yaduraju, Sr. Scientist, Divn. of Agronomy, IARI
18. Dr R K Rai, Sr. Scientist, Divn. of Agronomy, IARI
19. Dr S N Sharma, Sr. Scientist, Divn. of Agronomy, IARI
20. Dr Surendra Singh, Sr. Scientist, Divn. of Agronomy, IARI
21. Dr Attar Singh, Sr. Scientist, Divn. of Agronomy, IARI
22. Dr G Giri, Sr. Scientist, Division of Agronomy, IARI
23. Dr R K Singh, Sr. Scientist, Division of
24. Dr S N Singh, Sr. Scientist, Division of Agronomy, IARI
25. Dr Ranbir Singh, Sr. Scientist, Division of Agronomy, IARI
26. Dr R K Chhillar, Sr. Scientist, Division of Agronomy, IARI
27. Dr Mangal Prasad, Sr. Scientist, Division of Agronomy, IARI
28. Dr L K Idnani, Scientist, Division of Agronomy, IARI
29. Dr Ashok Kumar, Scientist, Division of Agronomy, IARI
30. Dr T K Das, Scientist, Division of Agronomy, IARI
31. Dr D S Rana, Scientist, Division of Agronomy, IARI
32. Dr B G Shivkumar, Scientist, Division of Agronomy, IARI •
33. Rajvir Sharma. Scientist, Division of Agronomy, IARI
34. Dr K S Rana, Scientist, Division of Agronomy, IARI
35. Sh. Ranjit Singh, Ph.D. student (Agronomy)

36. Sh. Hritik Biswas, Ph.D. student (SS&AC)
37. Sh. A Das, M.Sc. student (Agronomy)
38. Dr D K Singh, Research Associate, Agronomy
39. Dr Upendra Kumar, Research Associate, Agronomy
40. Mr Rajiv Kumar Singh, Research Fellow, Agronomy

B. State Agricultural Universities

41. Dr S Rami Reddy, Professor and University Head, Department of Agronomy, S V Agricultural College, Tirupati 517 502
42. Dr A Sambasiva Reddy, Department of Agronomy, ANGR Agric. University, Rajendranagar, Hyderabad 500 030
43. Dr N K Kalyansundaram, Head, Dept. of Agril. Chemistry, B.A. College of Agriculture, GAU, Anand 388 110
44. Dr A M Shekh, Head, Dept. of Meteorology, B.A. College of Agriculture, GAU, Anand 388 110
45. Dr M S Kuhad, Head, Dept. of Socil Sci. & Agril. Chem, CCSHAU, Hisar 125 004
46. Dr H L Sharma, Professor, Dept. of Agronomy, HPKVV, Palampur 176 062
47. Dr S D Sankhyan, Head, Dept. of Soil Science, HPKVV, Palampur 176 062
48. Dr A S Bali, Head, Dept. of Agronomy, SKUAST, Shalimar, Srinagar 191 121
49. Dr V B Nadagowda, Head, Department of Agronomy, Regional Res. Station, Raichur 584 101
50. Dr P A Sarangmath, Prof. & Head, Deptt. of Soil Sci. & Agril. Chemistry, College of Agriculture, UAS Dharwad 580 005
51. Dr K L Tiwar, Head, Dept. of Agronomy, College of Agriculture, JNKVV, Jabalpur
52. Dr R S Tripathi, Head, Dept. of Agronomy, IGAU, Raipur 492 012
53. Dr M L Adil, Head, Dept. of Soil Sci. & Agril. Chemistry, IGAU, Raipur 492 012
54. Prof. S S Solanki, Professor, Dept. of Agril. Meteorology, Centre of Advanced Studies in Agril. Meteorology, College of Agriculture, Pune 5
55. Dr J R Ramteke, Head, Dept. of Agronomy, College of Agriculture, Dapoli, KKV, Dist. Ratnagiri 415 712
56. Dr B A Lakhdive, I/c Dryland Research Centre & Acting Head, Dept. of Agronomy, Akola
57. Dr P K Mahapatra, Head, Dept. of Agronomy, College of Agriculture, OUAT, Bhubaneswar
58. Dr D Sahu, Head, Dept. of SS&AC, College of Agriculture, OUAT, Bhubaneswar
59. Dr R S Narang, Ex-Professor of Agronomy, PAU, 140-D, Kitchlu Nagar, Ludhiana 141 001
60. Dr J N Kaul, Professor, Dept. of Agronomy, PAU, Ludhiana 141 004
61. Dr V Beri, Head, Dept. of Soils, PAU, Ludhiana 141 004
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74. Dr S V Kaore, Manager (AS), IFFCO, New Delhi
75. Dr R K Tewatia, Chief Agronomist, FAI, New Delhi
76. Dr K N Tiwari, Director, PPIC-India, Gurgaon