Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 4 - Physical Science

- Agricultural Meteorology
- Agronomy
- Soil Science
- Agricultural Physics
- Organic Farming

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Compiled By

Dean & Director of Instruction Co-Ordination Committee of SAU's 2022-23

Restructured and Revised Syllabus

M.Sc. & Ph. D. (Agriculture)

In

Agricultural Meteorology

Submitted by

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Preamble

Agricultural Meteorology is a branch of Meteorology that deals with the effects and impacts of weather and climate on agriculture and allied sectors. Climate is a major influencing factor of crop production. Any change in climatic elements is bound to have either positive or negative impacts on agricultural production. The Agro-meteorologist requires not only a sound knowledge of Meteorology, but also of Agronomy, Plant Physiology and Plant and Animal Pathology, in addition to common agricultural practices. Agricultural Meteorology is of particular relevance to India because of the high dependence of our agriculture on monsoon rainfall which has its own vagaries. Further, it is very well recognized that climate is not static and issues such as climate change and global warming are receiving increasing attention. The objective of this discipline is to educate students on the understanding of climate and weather elements, principles and processes, and their impact on agricultural activities.

The reliable weather information is very much important for the decision making of farmers before and during the crop season for arranging the inputs and their optimum utilization. Timely Agromet advisory can save inputs (fertilizers, seeds, plant protection chemicals, etc.), labour as well as the crop (especially at the harvest time after the crop reaches physiological maturity). Establishment of District-level Agromet Unit at different KVK is a great initiative by the Central Government and newly designed syllabus will empower the students to work in such types of project most efficiently.

Recent advances in space-borne, air-borne, and ground remote sensing have improved the spatial and temporal capacity of the discipline for crop health monitoring, crop loss assessment, crop acreage estimation, etc. Advancement in computing power is enabling us to collect big data in agriculture, analyse it and arrive at conclusions, which helps to make farming a profitable business. The new syllabus will expose the students to micrometeorological measurements, crop weather models, the principles and practices of exploring remote sensing data, spatial analysis using Geographic information system (GIS), data analysis using computer programming with open source software like ‘R’ or/and ‘Python’.The overall objective of this discipline is to educate students on the understanding of climate and weather elements, principles and processes, and their impact on agricultural activities and restructured course will help the students to achieve their goal.

Committee on Agricultural Meteorology

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Subcommittees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Physical Sciences	Agricultural Meteorology	M.Sc. (Agriculture)	Ph.D.	Dr.Syed Ismail, ADP, CoA, VNMKV, Parbhani	Dr. M.G. Jadhav Professor (Agril. Meteorology), CoA, Parbhani (VNMKV, Parbhani)

Sub-Committee constituted for the finalization of common PG syllabi in Agricultural Meteorology Discipline

Sr. No	Name	
1	**Dr. Syed Ismail** Associate Dean and Principal College of Agriculture, VNMKV, Parbhani	**Chairman**
2	**Dr.V.A.Sthool** Head Dept. of Agril. Meteorology College of Agriculture, Pune, MPKV, Rahuri	Member
3	**Dr.P.R. Jaybhaye** Associate Professor Agril. Meteorology VNMKV, Parbhani	Member
4	**Dr.A.R. Tupe** Agrometeorologist AICRP on Agrometeorology, Dr.PDKV, Akola	Member
5	**Dr. S.V. Bagade** Asstt. Professor, Dept. of Agril. Meteorology College of Agriculture, Pune, MPKV, Rahuri	Member
6	**Dr.K.K. Dakhore** Agrometeorologist AICRP on Agrometeorology, VNMKV, Parbhani	Member
7	**Prof. G.N.Gote** Asstt. Professor, Dept. of Agril. Meteorology College of Agriculture, VNMKV, Parbhani	Member
8	**Dr.M.GJadhav** Professor Agril. Meteorology, VNMKV, Parbhani	**Member Secretary**

Implementation of New Curriculum

The universities offering PG programmes in Agricultural Meteorology need to be supported for establishing specialized laboratories equipped with state-of-the art equipment's/computers for conducting practical classes especially, Measurement of different air pollutants, ozone and aerosol optical thickness (AOT), Measurements of radiation, CO_2 and methane in animal farm house, Micrometerological measurements in crop, Crop simulation models etc.

One time catch up grant should be awarded to each SAU, offering PG programmes in Agricultural Meteorology for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in different discipline of Agricultural Meteorology in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Agricultural Meteorology will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Agricultural Meteorology throughout the country.
- Imparting quality education in Agricultural Meteorology.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Agricultural Meteorology

Nomenclature of Degree Programme

(a) M.Sc. Programmes

i) M.Sc. (Agriculture) Agricultural Meteorology

(b) Ph. D. Programmes

i) Ph.D. (Agriculture) Agricultural Meteorology

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.\
- Lecture schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

- **Master's Degree Programme**

B.Sc.(Agri.) / **B. Sc. (Hons.) Agriculture** under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

(Note:- In case B.Sc. Agriculture / B.Sc. (Hons.) Agriculture candidates are not available, B. Sc. (Hort.) / B.Sc. (Hons.) Horticulture / B. Sc. (Forestry) / B.Sc. (Hons.) Forestry may be considered subjected to completion of deficiency package)

- **Doctoral Degree Programme**

Master's degree in concerned discipline (Agricultural Meteorology) with minimum of 6.50/10 or equivalent percentage of marks and basedon CET score CET conducted by MAUEB or AIEEA – ICAR, Agricultural Universities (AUs) which have expressed their willingness to utilize NTAscores for their PG admissions. If required the scores will be provided by NTA.

Sr. No	Name of Department	Specialization in Ph. D	Eligibility criteria
1.	Agricultural Meteorology	Agricultural Meteorology	M.Sc. in Agricultural Meteorology

Credit Requirements

Course Details	Masters Degree	Doctoral Degree
Major Courses	20	15
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

Course Structure

M.Sc. Agricultural Meteorology

LIST OF CORE COURSES/ DEPARTMENT WISE SPECIALIZATION/ COMPULSORY/SUPPORTING COURSES

1. M.Sc. (Agriculture) Agricultural Meteorology

Course Code	Course Title	Credit Hrs.
AGM 501*	Fundamentals of Meteorology	2+1
AGM 502*	Fundamentals of Agricultural Meteorology	2+1
AGM 503	Crop-weather Relationships	2+0
AGM 504*	Agro-meteorological Measurements and Instrumentation	1+2
AGM 505	Crop Micrometeorology	2+1
AGM 506	Evapotranspiration and Soil Water Balance	2+1
AGM 507	Crop weather models	1+2
AGM 508	Applied Agricultural Climatology	1+2
AGM 509	Weather forecasting	2+1
AGM 510	RS and GIS Applications in Agricultural Meteorology	2+1
AGM 511	Strategic use of climatic information	2+1
AGM 512	Weather and climate risk management	2+0
AGM 513	Aerobiometeorology	2+1
AGM 591	Master's Seminar	1+0
	Total	**23+15=38**
AGM 591	Master's Research	0+30

***Compulsory Courses**

Semester wise courses offered based on credit requirement

Course Code	Semester	Course Title	Credit Hrs.
AGM 501*	I	Fundamentals of Meteorology	2+1
AGM 502*	I	Fundamentals of Agricultural Meteorology	2+1
AGM 503	I	Crop-weather Relationships	2+0
AGM 504*	II	Agro-meteorological Measurements and Instrumentation	1+2
AGM 505	II	Crop Micrometeorology	2+1
AGM 507	III	Crop weather models	1+2
AGM 508	II	Applied Agricultural Climatology	1+2
AGM 591	III	Seminar	1+0
Total			**12+9=21**
AGM 591	II-IV	Master's Research	0+30

Common Courses: (Non Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1
PGS 502	I	Technical Writing and Communications Skills	0+1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	II	Basic Concepts in Laboratory Techniques	0+1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	III	Disaster Management	1+0

Minor Courses/Disciplines:

Minor courses 500 series (08 credits) will be taken on the decision of the Student Advisory committeefrom following discipline/courses.

1. Agronomy
2. Soil Science
3. Agricultural Physics
4. Organic Farming
5. Plant Physiology
6. Agril. Entomology
7. Plant Pathology
8. Livestock Management
9. Horticulture
10. Any other related discipline

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
AGRON 501*	Modern Concepts in Crop Production	3+0
AGRON 505	Conservation Agriculture	1+1
AGRON 512	Dryland Farming and Watershed Management	2+1
SOIL 501*	Soil Physics	2+1
SOIL 508	Soil water and air pollution	2+1
AP 503	Fundamentals of Soil Physics	2+1
AP 504*	Mathematics in Agriculture	3+0
AP 511	Simulation of Soil, Plant and Atmospheric Processes	2+1
AGM 506	Evapotranspiration and Soil Water Balance	2+1
AGM 509	Weather forecasting	2+1
AGM 510	RS and GIS Applications in Agricultural Meteorology	2+1
AGM 511	Strategic use of climatic information	2+1
AGM 512	Weather and climate risk management	2+0
AGM 513	Aerobiometeorology	2+1

PP 501*	Principles of Plant Physiology I	2+1
PP 508	Physiology of Field Crops	2+0
PP 507	Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling	2+1

Optional/Supporting Courses/Disciplines:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agricultural Statistics
2. Computer Science and Information Technology
3. Agronomy
4. Agricultural Physics

Some of the suggestive courses are as given below.

Course Code	Course Title	Credit Hrs.
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502,	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
STAT 552	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 512	Information Technology in Agriculture	2+0
MCA 514	Statistical Computing	1+1

Compulsory Non Credit Deficiency Courses (those who are non-Agriculture Graduates)

Students other than Agriculture stream will be required to complete Noncredit deficiency courses of 400 series (6 to 10 credits) of B.Sc. Agriculture / B.Sc. (Hons.) Agriculture degree courses as decided by the Student Advisory committee.

Course Contents

M.Sc. (Agriculture) Agricultural Meteorology

AGM 501	**Fundamentals of Meteorology**	**2+1**

Theory
Unit I
Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation in pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anti cyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.
Unit II
Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit, Lapse rates-ascent of dry and moist air, stability and instability conditions in the atmosphere.
Unit III
Agromet observatory and analysis of weather data; Condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.
Unit IV
Effect of Earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; pressure belts and wind pattern on Earth globe, different forces acting on wind, the trade winds, equatorial trough and its movement, polar jet stream and tropical jet stream.
Unit V
Monsoon and its origin; Indian monsoon and its seasonal aspects: Onset, advancement and retreat of monsoon in different parts of India, Walker and Hadley cell, El Nino, La Nina, Western disturbances, Indian Ocean Dipole, Southern Oscillation Index and their impact on monsoon.
VI. 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.
• Weather chart preparation and identification of low pressure systems and ridges.
• Statistical technique for computation of climatic normals, moving average, etc.
VII. Teaching methods/activities
Classroom teaching and practical-classes, visit to Agromet Observatory
VIII. Learning outcome
Basic knowledge on meteorology and climatology, physical laws governing atmosphere and monsoon
IX. Suggested Reading
• Ahrens. 2008. *Meteorology today*, 9th Edition. Wadsworth Publishing Co Inc.
• Barry RG and Richard JC. 2003. *Atmosphere, Weather and Climate*. Tailor &Fransics Group.
• Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.

• Ghadekar SR. 2001. *Meteorology*. Agromet Publishers (Nagpur).
• Ghadekar SR. 2002. *Practical Meteorology*. Agromet Publishers (Nagpur).
• Mcllveen R. 1992. *Fundamentals of Weather and Climate*. Chapman & Hall.
• Petterson S. 1958. *Introduction to Meteorology*. McGraw Hill.
• Trewartha Glenn T. 1954. *An Introduction to Climate*. McGraw Hill.
• Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

Journals

• *Mausam*
• *Journal of Agrometeorology*
• *Italian Journal of Agrometeorology*
• *Theoretical and Applied Climatology*

Websites

• http://www.imd.gov.in/pages/main.php
• https://public.wmo.int/en

Lecture Schedule (AGM 501)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere;	2
2	Variation in pressure and temperature with height, potential temperature, pressure gradient,	2
3	Cyclonic and anticyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.	3
4	Gas laws, laws of thermodynamics and their application to atmosphere;	2
5	Water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit,	3
6	Lapse rates-ascent of dry and moist air, stability and instability conditions in the atmosphere.	2
7	Agromet observatory and analysis of weather data;	2
8	Condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes,.	2
9	Artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.	2
10	Effect of Earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind;	2
11	Pressure belts and wind pattern on Earth globe, different forces acting on wind, the trade winds,	2

12	Equatorial trough and its movement, polar jet stream and tropical jet stream.	2
13	Monsoon and its origin; Indian monsoon and its seasonal aspects:	2
14	Onset, advancement and retreat of monsoon in different parts of India,	2
15	Walker and Hadley cell, El Nino, La Nina, Western disturbances, Indian Ocean Dipole, Southern Oscillation Index and their impact on monsoon.	2
	Total	32

AGM 502 Fundamentals of Agricultural Meteorology 2+1

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Climatic change, adaptation, and mitigation. greenhouse effect, CO_2 increase, global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India.

VI. Practical

• Preparation of crop weather calendars

• Development of simple regression models for weather, pest and disease relation in different crops.

• Preparation of weather based agro-advisories

• Use of automated weather station (AWS)

VII. Teaching methods/activities

Classroom teaching and practical-classes, visit to Agromet Observatory

VIII. Learning outcome

Overall and basic knowledge on Agrometeorology

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book Co.
- Mahi and Kingra. 2014. *Fundamentals of agrometeorology*. Kalyani publishers.
- Mavi HS and Tupper. 2004. *Principles and applications of climate studies in agriculture*. CRC Press
- Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.

Journals

- *Journal of Agrometeorology*
- *Italian Journal of Agrometeorology*
- *Agricultural and Forest Meteorology*
- *Current Science*

Websites

- http://www.imd.gov.in/pages/main.php
- http://www.fao.org/home/en/
- www.wmo.org
- www.ipcc.org

Lecture Schedule (AGM 502)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Meaning and scope of agricultural meteorology; components of agricultural meteorology;	2
2	Role and responsibilities of agricultural meteorologists.	1
3	Importance of meteorological parameters in agriculture;	1
4	Efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation;	3
5	Basic principles of water balance in ecosystems; soil-water balance models and water production functions.	2
6	Crop weather calendars;	1
7	Weather forecasts for agriculture at short, medium and long range levels nowcast and extended weather forecast;	2
8	Agromet advisories, preparation, dissemination and economic impact analysis Feedback system of agromet advisory system;	2
9	Use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.	3
10	Concept, definition, types of drought and their causes; prediction of drought;	2
11	Crop water stress index, crop stress detection; air pollution and its influence on vegetation,	2
12	Meteorological aspects of forest fires and their control.	1

13	Climatic change, adaptation, and mitigation.	3
14	Greenhouse effect, CO2 increase, global warming and their impact on agriculture;	3
15	Climate classification,	2
16	Agro-climatic zones and agro-ecological regions of India.	2
	Total	32

AGM 503 Crop-weather Relationships 2+0

Theory

Unit I

Understanding the influence of weather elements on crop growth, impact of climatic Physical Sciences: Agricultural Meteorology variability and extremes on crop production, climatic normals for crop production.

Unit II

Climatic requirements of major crops, temperature effect on crop growth, radiation impact and radiation utlilization efficiency, humidity effect on crop performance, Heat units, effect of soil temperature on seed germination and root growth, wind variation and crop growth.

Unit III

Meteorological indices to predict crop production, Interpretation of weather forecasts for various agricultural operations towards improved productivity, crop-weather relationship in dryland areas. Crop weather relationship of major vegetable and horticultural crops of the region and agroforestry system.

Unit IV

Rhizosphere and microorganisms in relation to weather, fertilizer and water use efficiency in relation to weather.

VI. Teaching methods/activities

Classroom teaching

VII. Learning outcome

To enhance the knowledge on intricate relationship between crop and weather.

VIII. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Jerry L. Hatfield, Mannava VK, Sivakumar and John H. Prueger. 2017. *Agroclimatology: Linking Agriculture to climate*. Agronomy Monographs 60.
- Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.
- Prasada Rao GSLHV. 2008. *Agricultural Meteorology*. PHI Learning Publishers.

Journals

- *Journal of Agrometeorology*
- *Agricultural and Forest Meteorology*

Websites

- http://www.imd.gov.in/pages/main.php
- http://www.fao.org/home/en/

Lecture Schedule (AGM 503)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Understanding the influence of weather elements on crop growth,	1
2	Impact of climatic Physical Sciences: Agricultural Meteorology variability and extremes on crop production,	2
3	Climatic normals for crop production	1
4	Climatic requirements of major crops,	2
5	Temperature effect on crop growth,	1
6	Radiation impact and radiation utlilization efficiency,	2
7	Humidity effect on crop performance,	1
8	Heat units,	2
9	Effect of soil temperature on seed germination and root growth, wind variation and crop growth.	3
10	Meteorological indices to predict crop production,	2
11	Interpretation of weather forecasts for various agricultural operations towards improved productivity,	3
12	Crop-weather relationship in dryland areas.	2
13	Crop weather relationship of major vegetable crops of the region	3
14	Crop weather relationship of major horticultural crops of the region and agroforestry system	3
15	Rhizosphere and microorganisms in relation to weather,.	2
16	Fertilizer and water use efficiency in relation to weather	2
	Total	32

AGM 504 Agro-meteorological Measurements and Instrumentation 1+2

Theory

Unit I

Fundamentals of measurement techniques; theory and working principles of barometer, thermometer, psychrometer, hair hygrometer, thermohygrograph; exposure and operation of meteorological instruments/ equipments in agromet observatories.

Unit II

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

Unit III

Precipitation and dew instruments: working principles of rain gauge, self-recording rain gauge, Duvdevani dew gauges. Wind instruments: working principles of anemometer, wind vane, anemograph.

Unit IV

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

Unit V

Boundary layer fluxes, Flux tower, soil heat flux plates, instruments to measure soil moisture and soil temperature.

Unit VI

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

VI. Practical

- Working with the above instruments in the meteorological observatory, fields and laboratory, Recording observations of relevant parameters.
- Computation and interpretation of the data.
- Analysis of AWS data.
- Data logging, data retrieval and data quality assessment

VII. Teaching methods/activities

Mostly practical classes with demonstration and hands-on use of met-instruments

VIII. Learning outcome

Practical classes and theory

IX. Suggested Reading

- Anonymous. 1987. *Instructions to Observers at Surface Observatories*. Part I, IMD, New Delhi.
- Byers HR. 1959. *General Meteorology*. McGraw Hill.
- Ghadekar SR. 2002. *Practical Meteorology: Data Acquisition Techniques, Instruments and Methods*. Agromet Publ.
- Middleton WE and Spilhaws AF. 1962. *Meteorological Department*. University of Toronto Press.
- Tanner CB. 1973. *Basic Instrumentation and Measurements for Plant Environment and Micrometeology*. University of Wisconsin, Madison.
- WMO. 2008. *Guide to Meteorological Instruments and Methods of Observation*. WMO-No.8
- Jaybhaye PR.2013 Handbook of Agricultural Meteorology

Journals

- *International Journal of Biometeorology*
- *Agricultural and Forest Meteorology*
- *Journal of Agrometeorology*

Website

https://public.wmo.int/en

Lecture Schedule (AGM 504)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Fundamentals of measurement techniques;	1
2	Theory and working principles of barometer, thermometer, psychrometer,	1
3	Theory and working principles hair hygrometer, thermohygrograph;	1
4	Exposure and operation of meteorological instruments/ equipment's in agromet observatories	1
5	Radiation and temperature measuring instruments:	1
6	Working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder,	1
7	Working principles Quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.	2
8	Precipitation and dew instruments: working principles of rain gauge, self-recording rain gauge, Duvdevani dew gauges.	2
9	Wind instruments: working principles of anemometer, wind vane, anemograph.	1
10	Evapotranspiration and photosynthesis instruments:	1
11	Working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area	1
12	Boundary layer fluxes, Flux tower, soil heat flux plates,	1
13	Instruments to measure soil moisture and soil temperature.	1
14	Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.	1
	Total	16

AGM 505 Crop Micrometeorology 2+1

Theory

Unit I

Properties of atmosphere near the Earth's surface; micrometeorological divisions, structure of atmospheric boundary layer, exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection.

Unit II

Wind speed profile over the surface, laminar and turbulent flow, Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement, temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raynolds analogy, Exchange coefficients.

Unit III

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

Unit IV

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

VI. Practical

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

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge of microclimatic conditions governing crop growth

IX. Suggested Reading

• Pal AS. 1988. *Introduction to Micrometeorology*. Academic Press.
• Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
• Chang, Jen-Hu. 1968. *Climate and Agriculture: An Ecological Survey*. Aldine Publishing Company.
• Gates DM. 1968. *Energy Exchange in the Biosphere*. UNESCO.
• Goudriaan J. 1983. *Crop Micrometeorology: A Simulation Study*. Scientific Publ.
• Grace J. 1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
• Gupta PL and Rao VUM. 2000. *Practical Manual on Micrometeorology*. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
• Jones HG. 1992. *Plants and Microclimate*. Cambridge Univ. Press. Munn RE. 1970. Biometeorological Methods. Academic Press.
• Monteith and Unsworth. 2013. *Principles of Environmental Physics*. Elsevier.
• Rosenberg NJ. 1974. *Microclimate – The biological Environmet*. John Wiley & Sons.
• Sellers W. 1967. *Physical Climatology*. The University of Chicago Press.

Journals

• *International Journal of Biometeorology*
• *Agricultural and Forest Meteorology*
• *Journal of Agrometeorology*

Website

• https://public.wmo.int/en

Lecture Schedule (AGM 505)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Properties of atmosphere near the Earth's surface; micrometeorological divisions,	1
2	Structure of atmospheric boundary layer, exchange of mass momentum and energy between surface and overlaying atmosphere,	2
3	Exchange coefficient, similarity hypothesis, shearing stress, forced and free convection	1
4	Wind speed profile over the surface, laminar and turbulent flow, Molecular and eddy transport of heat	2
5	Water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement	2
6	Temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers,	1
7	Variation in microclimate under irrigated and rainfed conditions	1
8	Soil moisture and temperature variation with depth; Richardson number, Raynolds analogy, Exchange coefficients.	2
9	Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide;	2
10	Modification of microclimate due to cultural practices, intercropping;	2
11	Radiation distribution and utilization by plant communities, leaf temperature and its biological effects.	2
12	Influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields,	2
13	Microclimate within forests, glass house and plastic house climates;	2
14	Instruments and measuring techniques in micrometeorology.	2
15	Effects of ambient weather conditions on growth, development and yield of crops;	2
16	Measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces.	1
17	Net radiation measurement at different levels; PAR distribution in plant canopies and interception;	1
18	Wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation;	2

19	Remote sensing and its application in relation to micrometeorology		2
		Total	32

AGM 506 Evapotranspiration and Soil Water Balance 2+1

Theory

Unit I

Energy concept of soil water, hydraulic conductivity and soil water flux; theory on hydraulic conductivity in saturated and unsaturated soils; physical factors concerning water movement in soil; concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.

Unit II

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

Unit III

Influence of microclimatic and cultural factors on soil water balance; techniques of lysimetry in measuring actual evapotranspiration. water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, computation of Kc values and their use; irrigation schedulingbased on climatological approaches

Unit IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; estimation of evapotranspiration through remote sensing.

VI. Practical

- Measurement of various components of soil water balance
- Evaluation of hydraulic conductivity vs. soil moisture relationship by water balance approach
- Computation and comparison of evapotranspiration by different methods – energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Soil moisture retention characteristics by pressure plate method.
- Calculation of WRSI (Water requirement satisfaction index)

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

To know the estimation procedures and inter linkages among different components of field water balance

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Burman R and Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.
- Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
- Mavi HS and Tupper GJ. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
- Murthy VRK. 2002. *Basic Principles of Agricultural Meteorology*. BS Publ.

• Niwas R, Singh D and Rao VUM. 2000. *Pratical Manual on Evapotranspiration.* Dept. of Agril. Meteorology, CCS HAU Hisar.
• Rosenberg NJ, Blad BL and Verma SB. 1983. *Microclimate –The Biological Environment*. John Wiley & Sons.
• Subramaniam VP. 1982. *Water balance and its application*. Andhra University Press, Waltair, India.

Journals

• *Journal of Agrometeorology*
• *Archives of Agronomy and Soil Science*
• *Agricultural Water Management*
• *Journal of Hydrology*
• *Journal of Plant Ecology*

Websites

• https://www.icrisat.org/
• http://www.iwmi.cgiar.org/
• http://www.iiwm.res.in/

Lecture Schedule (AGM 506)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Energy concept of soil water, hydraulic conductivity and soil water flux;	2
2.	Theory on hydraulic conductivity in saturated and unsaturated soils;	2
3.	Physical factors concerning water movement in soil;	2
4.	Concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.	2
5.	Theories of evapotranspiration and their comparison;	2
6.	Aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions;	3
7.	Concepts of potential, reference and actual evapotranspiration - modified techniques.	2
8.	Influence of microclimatic and cultural factors on soil water balance;	1
9.	Techniques of lysimetry in measuring actual evapotranspiration.	2
10.	Water use efficiency and scheduling of irrigation based on evapotranspiration;	2
11.	Water use efficiency and antitranspirants, computation of Kc values and their use;	2
12.	Irrigation scheduling based on climatological approaches	2
13	Yield functions;	1
14	Water use efficiency and scheduling of irrigation based on evapotranspiration;	2

15	Dry matter yield ET functions; radiation instruments;	2
16	Advanced techniques for measurement of radiation and energy balance;	2
17	Estimation of evapotranspiration through remote sensing.	2
	Total	**32**

AGM 507 Crop Weather Models 1+2

Theory
Unit I
Principles of crop production; effect of weather elements on crop responses; impact of natural and induced variability of climate on crop production.
Unit II
Introduction and application to crop modeling, types of models, Empirical and statistical crop weather models their application with examples; concept of crop growth model in relation to weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models;
Unit III
Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc.; optimization, calibration and validation of models. Weather data and physiology based approaches to modeling of crop growth and yield; forecasting of pests and diseases; stochastic models; advantages and limitation of modeling.
VI. Practical
Working with statistical and simulation models, DSSAT models, InfoCrop, Oryza, etc.
VII. Teaching methods/activities
Theory and practical classes. Demonstration and hands-on practical's using crop models
VIII. Learning outcome
To utilize the crop weather model for observing weather influence on crop growth
IX. Suggested Reading
• Wallach D *et al.Working with dynamic crop models*.
• DeWit CT, Brouwer R and de Vries FWTP. 1970. *The Simulation of Photosynthetic Systems*. pp. 7-70. In. Prediction and Measurement of Photosynhetic Activity. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.
• Duncan WG. 1973. *SIMAI- A Model Simulating Growth and Yield in Corn*. In: The Application of Systems Methods to Crop Production (D.N. Baker, Ed.). Mississippi State Univ. Missisipi.
• Frere M and Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting*. FAO.
• Hanks RJ. 1974. *Model for Predicting Plant Yield as Influenced by Water Use*. Agron. J. 66: 660-665.
• Hay RKM and Porter JR. 2006. *The physiology of crop yield* (2nd Edition).
• Keulen H Van and Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop*. Simulation Monographs. PUDOC, Wageningen.
• Singh P. *Modelling of crop production systems: Principles and applications*.
• Weixing Cao *et al*. *Crop modeling and decision support.*
Journals
• *Journal of Agrometeorology*

- *Global Environmental Change*
- *Global Change Biology*
- *Mitigation and Adaptation Strategies for Global Change*

Websites

- https://www.apsim.info/
- https://dssat.net/

Lecture Schedule (AGM 507)

Sr. No	Topics to be Covered	No. of Lecture (s)
1	Principles of crop production	1
2	Effect of weather elements on crop responses;	1
3	Impact of natural and induced variability of climate on crop production.	1
4	Introduction and application to crop modeling,	1
5	Types of models,	1
6	Empirical and statistical crop weather models their application with examples;	1
7	Concept of crop growth model in relation to weather, soil, plant and other environmental related parameters	2
8	Remote sensing inputs; growth and yield prediction models;	2
9	Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc.;	2
10	Optimization, calibration and validation of models.	1
11	Weather data and physiology based approaches to modeling of crop growth and yield;	1
12	Forecasting of pests and diseases;	1
13	Stochastic models; advantages and limitation of modeling.	1
	Total	16

AGM 508 Applied Agricultural Climatology 1+2

Theory

Unit I

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

Unit II

Precipitation indices; Drought indices Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications;

assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

Unit III

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

Unit IV

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

VI. Practical

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

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge on how to use the meteorological observations and derived indices are applied in agricultural field

IX. Suggested Reading

- Anonymous 1980. *ICRISAT Climatic Classification – A Consultation Meeting*. ICRISAT.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Lal DS. 1989. *Climatology*. Chaitanya Publ. House.
- Mather JR. 1977. *Work Book in Applied Climatology*. Univ. of Delware, New Jersey.
- Mavi HS and Tupper Graeme J. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
- Stigter K (Ed.). 2010. *Applied Agrometeorology*. Springer
- Subramaniam VP. 1977. *Incidence and Spread of Continental Drought*. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.
- Thompson R. 1997. *Applied Climatology: Principles and Practice*. Routledge.
- Walter J Saucier. 2003. *Principles of Meteorological Analysis*. Dover Phoenix Eds.

Journals

- *Theoretical and Applied Climatology*
- *Atmospheric Research Journal*
- *Journal of Agrometeorology*
- *Agricultural Climatology and Meteorology*
- *Journal of Applied Meteorology and Climatology*

Websites

- http://www.imd.gov.in/pages/main.php
- https://public.wmo.int/en

Lecture Schedule (AGM 508)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Climatic statistics: measures of central tendency and variability,	1
2.	Skewness, kurtosis, homogeneity, correlation, regression and moving averages;	1
3.	Probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.	2
4.	Precipitation indices; Drought indices Climatic water budget: potential and actual evapotranspiration and their computation;	1
5.	Measurement of precipitation, calculation of water surplus and deficit;	1
6.	Computation of daily and monthly water budget and their applications;	1
7.	Assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications	1
8.	Thermal indices and phenology: cardinal temperatures;	1
9	Heat unit and growing degree day concepts for crop phenology, crop growth and development;	1
10	Insect-pest development; crop weather calendars;	1
11	Agroclimatic requirement of crops.	1
12	Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation;	2
13	Climate, housing and site orientation; climatic normals for animal production	2
	Total	**16**

AGM 509 Weather Forecasting 2+1

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

VI. Practical

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

VII. Teaching methods/ activities

Theory and practical classes

VIII. Learning outcome

Enhancing knowledge on weather forecast and its use

IX. Suggested Reading

- Watts A. 2005. *Instant Weather Forecasting*. Water Craft Books.
- Ram Sastry AA. 1984. *Weather and Weather Forecasting*. Publication Division, GOI, New Delhi.
- Singh SV, Rathore LS and Trivedi HKN. 1999. *A Guide for Agrometeorological Advisory Services*. Department of Science and Technology, NCMRWF, New Delhi.
- Wegman and Depriest. 1980. *Statistical Analysis of Weather Modification Experiments*. Amazon Book Co.

Journals

- *Journal of Climatology and Weather Forecasting*
- *Theoretical and Applied Climatology*
- *Atmospheric Research Journal*
- *Journal of Agrometeorology*
- *Agroclimatology*

Websites

- https://www.ipcc.ch/
- https://www.imd.gov.in/pages/main.php

Lecture Schedule (AGM 509)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Weather forecasting system: definition, scope and importance; types of forecasting: now cast, short, medium, long-range and extended	2

	weather forecast;	
2.	Study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and	2
3.	Weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.	2
4.	Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano-technological approach.	3
5.	Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior;	3
6.	Various methods of verification of location-specific weather forecast	2
7.	Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.	2
8.	Modification of weather hazards: weather modification for agriculture;	3
9.	Scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds,	3
10.	Modification of severe storms and electric behaviour of clouds.	3
11.	Weather based advisories	2
12.	Interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production;	3
13	Preparation of weather-based advisories and dissemination	2
	Total	**32**

AGM 510 RS and GIS Applications in Agricultural Meteorology 2+1

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

VI. 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 spectroradiometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

VII. Teaching methods/activities

Hands on practicals and theory

VIII. Learning outcome

Knowledge on RS-GIS technique for application in Agricultural Meteorology

IX. Suggested Reading

- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Campbell JB. 1996. *Introduction to Remote Sensing*, 2nd ed., The Guilford Press, New York.
- Colwell RN. (Ed.). *Manual of Remote Sensing*. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
- Curan PJ. *Principles of Remote Sensing*. ELBS/Longman.
- Georg Joseph 2005.*Fundamentals of Remote Sensing*. University Press (India).
- Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.
- Lilisand TM, Kiefer RW and Chipman JW. 2003. *Remote Sensing and Image Interpretation*, 5th ed., John Wiley & Sons, Inc., New York.
- Narayan LRA. 1999. *Remote Sensing and its Applications*. Oscar Publ.
- Panda BC. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.
- Patel AN and Surender Singh. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.

Journals

- *Journal of Global Environmental Change*

- *Journal of Remote Sensing and GIS*
- *Journal of Agrometeorology*

Websites

- https://www.nrsc.gov.in/
- http://www.imd.gov.in/pages/main.php
- https://public.wmo.int/en

Lecture Schedule (AGM 510)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.	2
2.	Characteristics of electromagnetic radiation and its interaction with matter;	2
3.	Spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions	2
4.	Imaging and non-imaging systems;	2
5.	Framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.	2
6.	Drone technology.	2
7.	Data acquisition system, data preprocessing, storage and dissemination;	3
8.	Digital image processing and information extraction	2
9.	Microwave remote sensing; visual and digital image interpretation;	2
10.	Introduction to GIS and GPS.	2
11.	Digital techniques for crop discrimination and identification;	2
12.	Crop stress detection - soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature;	2
13	Drought monitoring, monitoring of crop disease and pest infestation.	2
14	Use of satellite data in weather forecasting.	1
15	Soil resource inventory; land use/land cover mapping and planning; integrated watershed development;	2
16	Crop yield modeling and crop production forecasting.	2
	Total	**32**

AGM 511 Strategic Use of Climatic Information 2+1

Theory

Unit I

Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters in the concerned continent/ region/ country/ sub-region and their documented or remembered impacts; Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any.

Unit II

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

Unit III

Adoption of preparedness strategies: priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

Unit IV

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

Unit V

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

Unit VI

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

Practical

• Outlook for present land use and cropping patterns and possible alternatives from environmental point of view

• Recent trends in land use and cropping patterns

• Agro-meteorological services to increase farmers design abilities of land use and cropping patterns

• Systematic and standardized data collection on protection measures against extreme climate.

VI. Teaching methods/activities

Theory and practical classes

VII. Learning outcome

Application of climatic information for agriculture and natural resource management

VIII. Suggested Reading

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

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

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

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

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

Journals

• *Climate Risk Management*, *Journal* of *Climate* (JCLI),

• *International Journal of Climatology*

• *Journal of Agrometeorology*

Website

https://www.ncdc.noaa.gov/climate-information

Lecture Schedule (AGM 511)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters in the concerned continent/ region/ country/ sub-region and their documented or remembered impacts;	2
2.	Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any	2
3.	Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation; history of present land use and cropping patterns in the sub-region concerned as related to environmental issues;	3
4.	Successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.	2
5.	Adoption of preparedness strategies: priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.	2
6.	Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural production inputs and their history;	2

7.	Determination of input efficiencies based on weather conditions; other factors determining inputs and input efficiency;	2
8.	Actual use of inputs in main land use and cropping patterns of the region.	1
9.	Adoption of microclimate modification techniques: review of microclimate management and manipulation methods	2
10.	History of microclimate modification techniques practiced in the continent/ country/ sub-region concerned.	2
11.	Possible improvements in adoption of microclimate modification techniques,	2
12.	Given increasing climate variability and climate change; local trends in adoption of such techniques.	1
13	Protection measures against extreme climate: history of protection measures against extreme climate in the continent/ region/ country/ sub region concerned	2
14	Successes and difficulties experienced by farmers with present protection measures;	2
15	Outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.	3
	Total	**32**

AGM 512 Weather and Climate Risk Management 2+0

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

Challenges to coping strategies-combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

VI. Teaching methods/ activities

Theory classes

VII. Learning outcome

Knowledge on different weather extremes and how to modify weather to reduce risk

VIII. Suggested Reading

• Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmoshperic Science and Climate*. National Research Council, USA.
• Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
• Chritchfield HJ. 1994. *General Climatology*. Prentice Hall.
• Lenka D. 1998. Climate, Weather and Crops in India. Kalyani.
• Mavi HS and Graeme J Tupper. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
• Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH.
• Menon PA. 1989. *Our Weather*. National Book Trust.
• Pearce RP. 2002. *Meteorology at the Millennium*. Academic Press.
• Rosenberg NJ, Blad BL and Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.
• Samra JS, Narain P, Rattan RK and Singh SK. 2006. *Drought Management in India*. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

Journals

• *International Journal of Biometeorology*
• *Agricultural and Forest Meteorology*
• *Journal of Agrometeorology*

Website

• https://www.icrisat.org/

Lecture Schedule (AGM 512)

Sr. No.	Topic	No. of Lecture (s)
1.	Risk characterization – definitions and classification of risks; characterization of weather and climate related risks in agriculture.	2
2.	Water related risks; radiation/ heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.	2
3.	Risks in agricultural production,	1
4.	History of weather and climate as accepted risk factors in agriculture in the continent/ region/ country/ sub-region concerned and the related documented risk concepts; preparedness for weather and climate risks.	3
5.	Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; Modern tools including remote sensing and GIS in monitoring and combating droughts.	2
6.	Theories of weather modification; scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants.	2
7.	Protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses, etc.	3
8.	Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/ region/ country/ sub region concerned and their documented evidence of application to agricultural/farming systems;	2
9.	Strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.	2
10.	Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information;	3
11	Heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives;	2
12	Challenges for developing coping strategies including transferring risks through insurance schemes.	1

13	Challenges to coping strategies-combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses,	2
14	Basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer;	3
15	Application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.	2
	Total	**32**

AGM 513 Aerobiometeorology 2+1

Theory
Unit I
Definition and structure of Aerobiometeorology, role of Agrometeorology and Biogeography in forecasting pests and disease outbreak, insect movement in the atmosphere, intensification, Effect of weather and climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pestsand diseases. Influence of weather and climate on Migratory pests (Desert locust, BPH etc.).
Unit II
Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones. Effects of sudden weather changes and extreme weather conditions on population built-up of the pest, heat stress and heat related mortality, climate change impact on pest and diseases.
Unit III
Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases, management of segments of disease triangle: environment manipulation and host manipulation, weather based forewarning system for pest and diseases.
Unit IV
Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control, abiotic factor in soil borne disease management, Managing of pests & diseases in controlled environment, Environmental management for pest and disease
VI. Practical
• Identification of different pests
• Pest population, observations and their index calculation
• Identification of various diseases
• Disease initiation and their intensity, percent disease index
• Relation between weather parameters and pests and disease
VII. Teaching methods/activities
Classroom teaching and practical, visit to fields
VIII. Learning outcome
Knowledge on interactions between atmospheric processes and living organisms, mainly pest and diseases
IX. Suggested Reading
• Yazdani, SS and Agarwal ML. 2002. *Elements of insect ecology*. Narosa Publishing House.
• Odum EP. *Fundamentals of insect ecology*.

• Dhaliwal GS and Arora R. *Integrated pest management*.
• Jerry L. Hatfield and Ivan J. Thomason. 1982. *Biometeorology in integrated pest management,*
Academic press.

Journals

• *Aerobiologica*
• *Journal of Agrometeorology*
• *International Journal* of *Biometeorology*

Website

• http://www.imd.gov.in

Lecture Schedule (AGM 513)

Sr. No.	Topic	No. of Lecture (s)
1.	Definition and structure of Aerobiometeorology, role of Agrometeorology and Biogeography in forecasting pests and disease outbreak.	3
2.	Insect movement in the atmosphere, intensification, Effect of weather and climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pestsand diseases.	3
3.	Influence of weather and climate on Migratory pests (Desert locust, BPH etc.).	2
4.	Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones.	3
5.	Effects of sudden weather changes and extreme weather conditions on population built-up of the pest,	2
6	Heat stress and heat related mortality, climate change impact on pest and diseases.	2
7	Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases,	3
8	Management of segments of disease triangle:	1
9.	Environment manipulation and host manipulation, weather based forewarning system for pest and diseases.	3
10.	Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control,	3
11.	Abiotic factor in soil borne disease management.	2
12	Managing of pests & diseases in controlled environment,	3
13	Environmental management for pest and disease.	2
	Total	**32**

Ph.D. Agricultural Meteorology
Course Structure

Ph. D. (Agriculture) Agricultural Meteorology

Course Code	Course Title	Credit Hrs.
AGM 601*	Climate change and sustainable development	2+1
AGM 602	Meteorology of air pollution	2+2
AGM 603	Livestock and fisheries meteorology	2+2
AGM 604	Hydrometeorology	2+1
AGM 605	Analytical tools and methods for Agro-meteorology	1+1
AGM 606	Research and publication ethics	2+0
AGM 607	Environmental Physics for Agricultural Meteorology	3+0
AGM 608*	Computer Programs and Software for Agrometeorological data Management	1+1
AGM 691	Doctoral seminar	1+0
AGM 692	Doctoral seminar	1+0
	Total	**17+8 =25**
AGM 699	Doctoral Research	0+75

***Compulsory Courses**

Semester wise Core Courses offered based on credit requirement

Course Code	Semester	Course Title	Credit Hrs.
AGM 601*	I	Climate change and sustainable development	2+1
AGM 604	II	Hydrometeorology	2+1
AGM 605	III	Analytical tools and methods for Agro-meteorology	1+1
AGM 606	III	Research and publication ethics	2+0
AGM 607	II	Environmental Physics for Agricultural Meteorology	3+0
AGM 608*	I	Computer Programs and Software for Agrometeorological data Management	1+1
AGM 691	III	Doctoral seminar	1+0
AGM 692	IV	Doctoral seminar	1+0
		Total	**13+4 =17**
AGM 699		Doctoral Research	0+75

Minor Courses/Disciplines:

Minor courses of 600 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agronomy
2. Soil Science
3. Agricultural Physics
4. Organic Farming
5. Plant Physiology
6. Agril.Entomology

7. Plant Pathology
8. Livestock Management
9. Horticulture
10. Any other related discipline

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
AGRON 602	Recent trends in crop growth and productivity	2+1
AGRON 607	Stress Crop Production	2+1
AGM 602	Meteorology of air pollution	2+2
AGM 603	Livestock and fisheries meteorology	2+2
SOIL 601	Recent trends in soil physics	2+0
SOIL 607	Modelling of Soil Plant System	2+0
AP 601*	Principles of Soil Physics	2+1
AP 603	Crop Micrometeorology and Evapotranspiration	2+1
AP 607	Weather Hazards and its Management	2+0
PP 606	Global Climate Change and Crop Response	2+0

Optional/Supporting Courses/Disciplines:

Supporting/optional courses of 600 series (05 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agricultural Statistics
2. Computer Science
3. Soil Science
4. Agricultural Physics

Some of the suggestive courses are as given below

Course Code	Course Title	Credit Hrs.
STAT 604*	Advanced Statistical Methods	2+1
STAT 605	Modeling Techniques for Forecasting	2+1
STAT 612	Advanced Design of Experiments	2+1
MCA 603	Simulation and Modeling	1+1

Ph.D. (Agriculture) Agricultural Meteorology

AGM 601 Climate change and Sustainable development 2+1

Theory

Unit I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; Case studies on various climatic projections and consequences thereof in relation to agriculture.

Unit II

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

Unit III

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

Unit IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; Clean Development Mechanism (CDM) and land use, Crop management options for low emission, land use change and forestry mechanism, alternate energy sources, etc.

Unit V

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

VI. Practicals

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

• Advance methodology of assessing the impact of climate change on crops

VII. Teaching methods/ activities

Classroom teaching, showing climatic models (GCMs and RCMs) though PPT, Hands on practical

VIII. Learning outcome

Will be aware on causes, impacts, mitigation and adaptations to climate change in the field of agriculture

IX. Suggested Reading

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

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

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

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

• Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses*. Cambridge Univ. Press.
• Pretty J and Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.
• Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.
• Salinger J, Sivkumar MVK and Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.
• Sinha SK. 1998. *Dictionary of Global Climate Change*. Commonwealth Publ.

Journal

• *Mitigation and Adaptation strategies for Global Change*
• *Climate Change*
• *Climate Risk Management*
• *Journal of Agrometeorology*

Website

• https://www.ipcc.ch/
• www.environment.gov.au/climate-change/climate-science-data/climate-science/ipcc

Lecture Schedule (AGM 601)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1.	Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, Ozone depletion; past records, present trends	2
2.	Extreme weather events and future projections	2
3.	Case studies on various climatic projections and consequences thereof in relation to agriculture.	2
4	Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security	2
5	Impacts of climate change on hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems	3
6.	Impacts of climate change on human health; human settlements, energy, and industry; insurance and other financial services	2
7.	Climate change and crop diversification, loss of biodiversity, microbes and pest dynamics	2
8	Climate change and storage, climate change and weed management.	1
9	Advance methodology of assessing the impact of climate change on crops.	1
10	Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme	3

	weather events	
11	Regional scenarios of climate change and variability.	1
12	Mitigation strategies for sustainable development	1
13	International policies, protocols, treaties for reduction in greenhouse gases and carbon emissions	2
14	Carbon sequestration; carbon credit; Clean Development Mechanism (CDM) and land use,	2
15	Crop management options for low emission, land use change and forestry mechanism, alternate energy sources, etc.	2
16	Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc;	2
17	Increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods, etc.	2
	Total	32

AGM 602 Meteorology of Air Pollution 2+2

Theory

Unit I

Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution, Real time air quality index and National air quality index.

Unit II

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

Unit III

Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; Planetary Boundary Layer (PBL) and mixing layer; meteorological conditions and typical plume forms; air pollution forecasting – Gaussian diffusion models, Numerical dispersion models.

Unit IV

Air quality standards; effect of air pollution on biological organisms and crops; ozone layer depletion; air pollution control technologies; management of air pollution; principles of diffusion of particulate matter in the atmosphere; air pollution laws and standards. Scales of air pollution: local, urban, regional, continental and global.

Unit V

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

VI. Practicals

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

VII. Teaching methods/activities

Classroom teaching and practical

VIII. Learning outcome

Knowledge of sources and dispersal of pollutants, indexing, the influence of meteorological activities and analysis of pollutants

IX. Suggested Reading

- Arya SP. 1998. *Air Pollution Meteorology and Dispersion*. Oxford Univ. Press.
- Oke TR. 1988. Boundary Layer Climates. Routledge.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Chhatwa GR. 1989. *Environmental Air Pollution and its Control*. Anmol Publ.
- Mishra PC. 1990. *Fundamentals of Air and Water Pollution*. Ashish Publ.
- Mudd J Brian and Kozlowski TT. (Ed.). 1975. *Responses of Plants to Air Pollution*. Academic Press.
- Pickett EE. 1987. Atmopheric Pollution. Hemisphere Publ. Corp.
- Sharma SH and Khan TI. 2004. *Ozone Depletion and Environmental Impacts*. Pointer Publ.
- Weber E. 1982. *Air Pollution Assessment Methodology and Modeling*. Plenum Press.
- Yunus M and Iqbal M. (Eds.). 1996. *Plant Response to Air Pollution*. John Wiley & Sons.

Journals

- *Atmospheric Pollution* Research,
- *Environmental Pollution,*
- *Journal of Agrometeorology*

Website

- https://www.nationalgeographic.com/environment/global-warming/pollution/

Lecture Schedule (AGM 602)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Introduction to air pollution- history, definition	1
2	Clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution	2
3	Real time air quality index and National air quality index.	1
4	Sources of air pollution; classification and properties of air pollutants;	2
5	Emission sources, importance of anthropogenic sources	1
6	Behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.	2

7	Acid rain and development of Gas Washing	1
8	Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution	2
9	Planetary Boundary Layer (PBL) and mixing layer; meteorological conditions and typical plume forms;	2
10	Air pollution forecasting – Gaussian diffusion models, Numerical dispersion models.	2
11	Air quality standards; effect of air pollution on biological organisms, Ozone layer depletion	2
12	Air pollution control technologies; management of air pollution;	2
13	Principles of diffusion of particulate matter in the atmosphere	2
14	Air pollution laws and standards. Scales of air pollution: local, urban, regional, continental and global	2
15	Air pollution sampling and measurement	2
16	Types of pollutant sampling and measurement, ambient air sampling,	2
17	collection of gaseous air pollutants, collection of particulate pollutants, stock sampling;	2
18	Analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.	2
	Total	32

AGM 603 Livestock and Fisheries Meteorology 2+2

Theory

Unit I

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

Unit II

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

Unit III

Meteorological conditions prevailing in glass-house, green house, animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors. Environmental modification within the shelters of livestock. Applications of biometeorological information for rational planning, design and management. Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

Unit IV

Livestock production and climate change, Management of livestock to reduce greenhouse gas emission.

Unit V

Weather effect on fish behaviour. Water temperature affecting fish activity. Marine weather and fishing. Climate change and fisheries production.

VI. Practical

- Measurement of meteorological parameters within the shelters of livestock
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of enegy fluxes on body
- Measurements of CO_2 and methane in animal farm house.

VII. Teaching methods/activities

Class room teaching for theory part, visit to farm house for practical

VIII. Learning outcome

Enhanced knowledge on weather influence on livestock and farm environment

IX. Suggested Reading

- GSLHV Prasada Rao, GG Varma and Beena (Eds). 2017. *Livestock meteorology*. New India Publishing Agency- Nipa. 542 pages
- Kaiser HM and Drennen TE. (Eds). 1993. *Agricultural Dimensions of Global Climate Change*. St. Lucie Press, Florida.
- Monteith L and Unsworth M. 2007. *Principles of Environmental Physics*. 2nd Ed. AcademicPress. Takahashi J, Young BA, Soliva CR and Kreuzer M. 2002. *Greenhouse Gases and Animal Agriculture*. Proc. 1st International Conference on Greenhouse Gases and Animal Agriculture.
- Tromp SW. 1980. *Biometeorology. The Impact of the Weather and Climate on Humans & their Environment*. (Animals and Plants). Heyden& Son Ltd.

Journals

- *Agricultural and Forest Meteorology,*
- *Journal* of *Animal Behaviour and Biometeorology,*
- *Journal of Agrometeorology*

Website

- www.wmo.org

Lecture Schedule (AGM 603)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.	2
2	Animal traits and physiological responses.	1
3	Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sunburns and photosensitive disorders	3
4	Meteorological conditions prevailing in glass-house, green house	2

5	Meteorological conditions prevailing animal shed, poultry house and grain storage barns;	2
6	Heating, cooling and ventilation of animal shed, poultry house and grain storage barns as governed by meteorological factors.	2
7	Environmental modification within the shelters of livestock.	2
8	Applications of biometeorological information for rational planning, design and management.	2
9	Weather and animal diseases and parasites;	2
10	Diseases of poultry and its relation with weather and thermal comfort.	2
11	Livestock production and climate change,	2
12	Management of livestock to reduce greenhouse gas emission.	2
13	Weather effect on fish behaviour.	2
14	Water temperature affecting fish activity.	2
15	Marine weather and fishing.	2
16	Climate change and fisheries production.	2
	Total	32

AGM 604 Hydrometeorology 2+1

Theory

Unit I

Hydrologic cycle and its modification; rainfall and its interception by plants and crops. Interpolation and measurement of missing rainfall data; adequacy of rain gauges; average rainfall on an area depth basis; presentation and processing of precipitation data.

Unit II

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, plant available water, cultural practices on soil moisture in relation to different phases
of crop growth; evaporation from snow, lakes, reservoirs and crop fields.

Unit III

Classifying rainfall data into class interval; ranking of rainfall data; relationship between intensity and duration; methods of predicting runoff rate; factors affecting runoff; rainfall-runoff relation; estimation of evapotranspiration from water balance methods; response of crops to water stresses under different agroclimatic situation on India.

Unit IV

Moisture availability indices and their application for Indian condition; wet and dry spell by Markov-chain model; drought and its classification, hydrological drought, drought indices and their applications under Indian conditions.

VI. Practical

• Analysis of rainfall data
• Determination of effective rainfall
• To estimate missing rainfall data for a given station.
• To find out the optimum number of rain gauges for a given catchment.
• To find out the mean rainfall for a given drainage basin by Thiessen polygon method and isohyetal method.
• To estimate the volume of runoff by SCS method.
• Estimation of evopotranspiration from field based water balance method.

VII. Teaching methods/activities

Theory and practical classes

VIII. Learning outcome

Knowledge on rainfall analysis, runoff estimation, calculation of evaporation and the relationship among different hydrological parameters

IX. Suggested Reading

• Chow, VenTe (Ed.). 1964. *Handbook of Applied Hydrology*. McGraw-Hill.
• Hillel D. 1971. *Soil and Water.* Academic Press.
• Hillel D. 1980. *Application of Soil Physics*. Academic Press.
• Hillel D. 1998. *Environmental Soil Physics*. Academic Press.

Journal

• *Journal* of *Hydrology*, *Journal* of *Hydrology and Meteorology,*
• *Agricultural Water Management,*
• *Journal of Agrometeorology*

Website

• https://has.arizona.edu/meteorology-hydrology-and-hydrometeorology
• www.abb.com/cawp/seitp161/4f39ac092c0598c9c1256fb8004f7726.aspx

Lecture Schedule (AGM 604)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Hydrologic cycle and its modification;	2
2	Rainfall and its interception by plants and crops.	1
3	Interpolation and measurement of missing rainfall data;	2
4	Adequacy of raingauges; average rainfall on an area depth basis;	3
5	Presentation and processing of precipitation data.	1
6	Measurement of runoff,	2
7	Infiltration, moisture retention of soil, percolation, evaporation, evapotranspiration and its importance to agriculturists, irrigation engineers and flood forecasting personnel;	3
8	Water holding capacity of soils, plant available water,	1
9	Cultural practices on soil moisture in relation to different phases of crop growth;	1
10	Evaporation from snow, lakes, reservoirs and crop fields.	1

11	Classifying rainfall data into class interval; ranking of rainfall data; relationship between intensity and duration;	2
12	Methods of predicting runoff rate (Rational formula, curve number method, Use of remote sensing and GIS, soil conservation service method)	2
13	Factors affecting runoff;	1
14	Rainfall-runoff relation;	1
15	Estimation of evapotranspiration from water balance methods;	2
16	Response of crops to water stresses under different agroclimatic situation on India.	2
17	Moisture availability indices and their application for Indian condition;	2
18	Wet and dry spell by Markov-chain model;	1
19	Drought and its classification, hydrological drought, drought indices and their applications under Indian conditions.	2
	Total	32

AGM 605 Analytical Tools and Methods for Agro-meteorology 1+1

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

VI. Practical

- Calculation of continentality factors.

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

VII. Teaching methods/activities

Theory and practical classes, learning of computer language

VIII. Learning outcome

Knowledge on collection of agromet data, sampling design for agrometeorology, calculation of different indices and analysis of data

IX. Suggested Reading

• Cooper M. 2006. *The Spirit of C. An Introduction to Modern Programming*. Jaico Publ.
• Malczewski J. 1999. *GIS &Multicriteria Decision Analysis*. John Wiley & Sons.
• WMO. 2010. *Guide to agricultural meteorological practices*. Chapter 3: agricultural meteorological data, their presentation and statistical analysis

Journals

• *The International Journal* of *Database Management* Systems
• Journal of Agrometeorology

Website

• https://www.tropmet.res.in/~icrp/icrpv12/adach.html
• www.wmo.int/pages/prog/wcp/agm/gamp/documents/WMO_No134_en.pdf

Lecture Schedule (AGM 605)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Review of agro-climatic methods;	1
2	Characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.	1
3	Network spacing; spatial and temporal methods;	1
4	GIS fundamentals and applications;	1
5	Numerical characterization of climatic features;	1
6	Crop response to climate, time lags, time and distance constants, hysteresis effects.	1
7	Influence of climate on stress-response relations;	1
8	Thermal time approach in agroclimatology- heat and radiation use	1

	efficiency in crop plants; applications to insect-pest development and prediction	
9	Comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.	2
10	Instrumentation and sampling problems; design of agro-meteorological experiments.	2
11	Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual basic.	1
12	Empirical and statistical crop weather models and their application with examples;	1
13	Incorporating weather, soil, plants and other environment related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation models; forecasting models for insects and diseases.	2
	Total	16

AGM 606 Research and Publication Ethics 2+0

Theory

Unit I

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II

Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit III

Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV

Publication ethics: Definition, introduction and importance. Best practices/ standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship,Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI

Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Unit VII

Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, Gindex, i 10 index altmetrics

V. Teaching methods/activities

Classroom teaching and field and laboratory activities

VI. Learning outcome

To familiarize the students about field and laboratory activities to be performed during the study period.

Lecture Schedule (AGM 606)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Introduction to philosophy: definition, nature and scope, concept, branches	2
2	Ethics: definition, moral philosophy, nature of moral judgements and reactions	2
3	Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity	2
4	Scientific misconducts- falsifications, fabrications and plagiarism (FFP)	2
5	Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data	3
6	Publication ethics: Defination, introduction and importance. Best practices/ standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest.	3
7	Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship,	3
8	Identification of publication misconduct, complaints and appeals, predatory publishers and journals	1
9	Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self archiving policies;	2
10	Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools, viz., JANE, Elsevier Journal Finder, Springer Journal Suggester etc.	3
11	Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad.	3
12	Software tools: Use of plagiarism software like Turnitin, Urkund and	2

	other open source software tools.	
13	Database and Research metrics: Indexing data base, citation database, web of science, scopus, etc.	2
14	Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, Gindex, i 10 index altmetrics	2
	Total	32

AGM 607 Environmental Physics for Agricultural Meteorology 3+0

Theory

Unit I

Thermodynamics of the atmosphere. Physics of radiation: origin and nature of radiation, radiation geometry in Cartesian, spherical cylindrical coordinate systems, conservation principles for radiant energy; fluid motion: laminar and turbulent transfer, fluctuation theory for turbulent transfer of momentum, heat and water vapour.

Unit II

Physics of evaporation: aerodynamic approach, energy balance approach and combination approach for evaporation estimates.

Unit III

Physics of soil water system: the concept of potential as applied to soil water system, total potential and components, movements of water on soil, fundamental equation, hydraulic conductivity, infiltration, field drainage and water vapour movement in soil.

Unit IV

Physics of water use: a physical introduction to plant-water system and relationships, water transport through soil-plant-atmosphere systems, measurement of crop water use in terms of water conservation equation.

VI. Teaching methods/activities

Classroom teaching

VII. Learning outcome

Knowledge and application of physical laws governing the agrometeorological parameters.

VIII. Suggested Reading

• Hillel D. 1971. *Soil and Water.* Academic Press.
• Hillel D. 1980. *Application of Soil Physics*. Academic Press.
• Hillel D. 1998. *Environmental Soil Physics*. Academic Press.
• Monteith JL .1973. *Principles of Environmental Physics.* Edward Arnold.
• Rose CW. 1966. *Agricultural Physics.* Pergamon Press.
• Sellers WD. 1965. *Physical Climatology*. University of Chicago Press.
• Van Wizk WR. 1963. *Physics of Plant Environment.* North-Holland Publishing.
• Waggoner PE. (Ed.). 1965. *Agricultural Meteorology.* American Meteorological Society.

Journals

• *Journal of Meteorological Research,*
• *Agricultural and Forest Meteorology*

Website

•https://fmph.uniba.sk/.../enviromentalna-fyzika-obnovitelne-zdroje-energie-meteorolo...

Lecture Schedule (AGM 607)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Thermodynamics of the atmosphere.	2
2	Physics of radiation: origin and nature of radiation,	3
3	Radiation geometry in Cartesian, spherical cylindrical coordinate systems	4
4	Conservation principles for radiant energy;	3
5	Fluid motion: laminar and turbulent transfer, fluctuation	3
6	Theory for turbulent transfer of momentum, heat and water vapour.	4
7	Physics of evaporation: aerodynamic approach,	3
8	Energy balance approach and combination approach for evaporation estimates.	4
9	Physics of soil water system: the concept of potential as applied to soil water system,	4
10	Total potential and components, movements of water on soil,	3
11	Fundamental equation, hydraulic conductivity, infiltration, field drainage and water vapour movement in soil.	4
12	Physics of water use: a physical introduction to plant-water system and relationships,	4
13	Water transport through soil-plant-atmosphere systems,	3
14	Measurement of crop water use in terms of water conservation equation.	4
	Total	48

AGM 608 Computer Programs and Software for Agrometeorological Data Management 1+1

Theory

Unit I

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

Unit II

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

Unit III

Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research. Availability, accessibility and security of data; evaluating the cost of data; e-management of data. Meta analysis: Advantages and problems, Steps, Approaches and methods, Applications.

Unit IV

Computer Programming: History, Quality requirements, Readability of source code, Algorithmic complexity, Debugging, Programming languages.

VI. Practical

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

VII. Teaching methods/activities

Hands on practical and theory

VIII. Learning outcome

Learning computer programming to manage and analyze agromet data

IX. Suggested Reading

- Ghadekar R. 2002. *Practical Meteorology – Data Acquisition Techniques, Instruments and Methods*. 4th Ed. Agromet Publ.
- IMD/ WHO. 1988. *Users Requirements for Agrometeorological Services.* IMD.
- Miles MB and Huberman AM. 1994. *Qualitative Data Analysis*. Sage Publ.
- Panse VG and Sukhatme PV. 1983. *Statistical Methods for Agricultural Workers,* ICAR.
- Potter GB. 1994. *Data Processing: An Introduction*. Business Publ.
- Ramakrishnan R and Gehrke J. 2003. *Database Management System*. McGraw-Hill.
- Sinha PK and Sinha P. 2004. *Computer Fundamentals*. BPB Publications. (6th Edn).

Journals

- *The Journal* of *Database Management*
- *International Journal* of Data Mining
- *Modelling and Management*

Websites

- https://www.cics.umass.edu/research/area/data-management
- https://www.referenceforbusiness.com/management/.../Data-Processing-and-Data-Man.

Lecture Schedule (AGM 608)

Sr. No.	Topics to be Covered	No. of Lecture (s)
1	Data and information; types of data; climate, soil and crop data; Importance of database management	1
2	Softwares related to database management; data requirements; data collection and recording (Automatic and manual).	2
3	Data structure/format; quality control of data through computer software;	1

4	Techniques of climatic data generation; missing data;	2
5	Introduction to different software for database management.	1
6	Processing and analysis of data and data products;	1
7	Value addition of data and data products; data users, public, commercial, academic or research.	1
8	Availability, accessibility and security of data; evaluating the cost of data; e-management of data.	1
9	Meta analysis: Advantages and problems, Steps, Approaches and methods, Applications.	1
10	Computer Programming: History, Quality requirements	2
11	Readability of source code, Algorithmic complexity, Debugging,	1
12	Programming languages: C. C++, Java, Python	2
	Total	16

A list of international and national reputed Journals

Sr. No	Name of international and national reputed journals	NAAS Score
1	Mausam	6.64
2	Global Change Biology	16.86
3	Journal of Applied Meteorology and Climatology	8.92
4	Journal of Hydrology	11.72
5	Mitigation and Adaptation Strategies for Global Change	9.58
6	Agricultural and Forest Meteorology	11.73
7	Agricultural Water Management	10.52
8	Archives of Agronomy and Soil Science	9.09
9	Atmospheric Pollution Research	10.35
10	Current Science	7.10
11	Environmental Pollution	14.07
12	Global Environmental Change	15.52
13	International Journal of Biometeorology	9.79
14	Journal of Agrometeorology	6.55
15	Journal of Climate (JCLI)	11.15
16	Journal of Plant Ecology	7.77

Restructured and Revised Syllabus

M.Sc. & Ph. D. (Agriculture)

in

Agronomy

Submitted by

Broad Subject Coordinator
Associate Dean and Principal
College of Agriculture, VNMKV, Parbhani

Discipline Coordinator
Prof.(Agronomy),
College of Agriculture, Pune
MPKV, Rahuri

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Discipline: Agronomy

Preamble

Agronomy is a discipline which deals with various processes such as cultivation, interculture, management of field through various measures like weed management, soil fertility development, proper use of water resources and so on. Agronomy has a major component of agro ecology which includes several activities that affect the environment and human population. An Agronomist remains in the Centre of effort to work with issues related to environmental and ecological concerns and to increase the production of food, eed ,fuels and fibre for growing population in world. Agronomist today are involved with many issues including producing food, creating healthier food, managing environmental impacts and creating energy from plants. Research activities in Agronomy focus on system analysis and simulation modeling of environmental and management impacts on agricultural production, these are key to the sustainability of agricultural production system.

Hence, it is very much essential to revise the course curriculum of Agronomy so that students even teachers may be well acquainted with the present concept of development of the discipline. This will help bringing competency in students along with confidence so as to develop himself/herself for being tackling field problems and management of land. The existing M.Sc. (Ag) courses of Agronomy have been modified taking into account of present day need by incorporating the necessary and important topics in the respective courses.

Minor changes have been made in most of the existing courses. As a part of course curriculum, M. Sc. (Ag) Agronomy was restructured to equip students to tackle emerging issues by inclusion of one new course on “Conservation agriculture”. All the Ph.D. courses of Agronomy was slightly revised by adding/deleting some portion in the existing courses. The course “Fundamentals of Meteorology” is dropped from Agronomy department and interested students can take the course from department of Agril. Meteorology. The course “Agroecology” offered by the department for Ph D programme is also dropped. Similarly, the PhD course “Crop production and system modeling” is also deleted and the contents are merged with Agron 601 i.e. “Current trends in Agronomy”.

It was proposed by some members to include new courses like “Seed production technology”, “Experimental technique in Agronomy” and “Management of Problem soils and water “. But finally, it was decided that these courses should be offered by the core departments such as Department of Seed Technology, Department of Statistics and Department of Soil Science, respectively. There are few courses in the existing syllabus which are not offered by in many universities. Hence, these courses are merged andthereby reduced the number of courses to limit choice so that complete knowledge of the subject can be given to the students. In all the courses, the practical aspects are strengthened.

Topics such as automated irrigation systems, value chain addition/post harvest processing, variable rate application, precision farming, protected agriculture, soil less farming, farm mechanization of practical operations, practical applications of advanced tools for big data analysis and interpretation, artificial intelligence, drones etc are included in the revised syllabus so that students can show competency at national and international level.

Committee on Agronomy

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub-Committees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Physical Science	**Agronomy**	M.Sc. (Agri.)	Ph.D.	**Dr. Syed Ismail,** ADP, CoA, VNMKV, Parbhani	**Dr. A.B. Kamble** Prof.(Agronomy), CoA, Pune (MPKV, Rahuri)

Sub-Committeeconstitutedfor thefinalization of common PG syllabi in Agronomy Discipline

	Sub-Committee	
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27	**Dr. A.S. Jadhav,** Professor (Agronomy)& DDR, VNMKV, Parbhani Mobile: Email:	**Member**
28	**Dr. G. A. Bhalerao,** Asso. Prof. Agronomy,VNMKV, Parbhani Mobile: Email:	**Member**
29	**Dr. I.A.B. Mirza,** Asstt. Prof. Agronomy, CoA, Parbhani Mobile: Email:	**Member**
30	**Dr. A.B. Kamble,** Professor. (Agronomy), CoA, Pune (MPKV, Rahuri) Mobile: 9421911396 Email: drarunkamble@gmail.com	**Member Secretary**

Implementation of New Curriculum

The universities offering PG programmes in Agronomy need to be supported for establishing specialized laboratories equipped with state-of-the art equipment for conducting practical classes especially, Water management, Weed management, Conservation Agriculture, Geoinformatics, Precision Agriculture, Nano technology &Organic farming.

One-time catch-up grant should be awarded to each SAU, offering PG programmes in Agronomy for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in Agronomy discipline in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Agronomy will be considered at par with the recommended M.Sc. & Ph.D. programme by Vth Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of Agronomy throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need offarmers governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:
M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Name of the Departments / Divisions
- Agronomy

Nomenclature of Degree Programme

(a) M.Sc. Programmes

i) M.Sc. (Agriculture) Agronomy

(b) Ph.D. Programmes

i) Ph.D. (Agriculture) Agronomy

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 550, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 560 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:
- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 500/600 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

Master's Degree Programme

B.Sc.(Agri.) / **B. Sc. (Hons.) Agriculture** under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

(Note:- In case B.Sc. Agriculture / B.Sc. (Hons.) Agriculture candidates are not available, B. Sc. (Hort.) / B.Sc. (Hons.) Horticulture / B. Sc. (Forestry) / B.Sc. (Hons.) Forestry may be considered subjected to completion of deficiency package)

Doctoral Degree Programme

Master's degree in concerned discipline with minimum of 6.50/10 or equivalent percentage of marks and based on CET score CET conducted by MAUEB or AIEEA – ICAR, Agricultural Universities (AUs) which have expressed their willingness to utilize NTA scores for their PG admissions. If required the scores will be provided by NTA.

(i) Master Degree in the concerned Department/Discipline of Agronomy and having appearing the Common Entrance Test of Agronomy subject conducted bycompetent authority.

Sr. No	Name of Department	Specialization in Ph. D Agronomy	Eligibility criteria
1.	Agronomy	Ph. D (Agriculture) Agronomy	M.Sc. Agronomy

Credit Requirements

Course Details	Master's Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

Common Courses: (Non-Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1=1
PGS 504	I	Basic Concepts in Laboratory Techniques	0+1=1
PGS 502	II	Technical Writing and Communications Skills	0+1=1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0=1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0=1

Optional Courses :

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Soil Science
2. Organic Farming
3. Horticulture
4. Irrigation and Water Management
5. Soil and Water conservation

Some of the suggested courses are

Course Code	Semester	Course Title	Credit Hrs.
STAT 502,	I	Statistical Methods for Applied Sciences	**3+1=4**
STAT 511	II	Experimental Designs	**2+1=3**
STAT 522	II	Data Analysis Using Statistical Packages	**2+1= 3**
COM 501	II	Information Technology in Agriculture	**2+1=3**

Minor Disciplines:

1. Natural Resource Management
2. Seed Science and Technology
3. Plant Physiology
4. Soil Science
5. Agricultural Meteorology
6. Plant Protection(Plant Pathology, Entomology etc.)
7. Microbiology
8. Organic Farming
9. Forestry

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
SOIL 501	Soil Physics	2+1=3
SOIL 509	Remote sensing and GIS technique for soil and crop studies	2+1=3
SOIL 504	Soil mineralogy, genesis and classification	2+1=3

AGM 503	Crop-weather Relationships	2+0=2
AGM 507	Crop weather models	1+2=3
AGM 512	Weather and climate risk management	2+0=2
AC 508	Agrochemicals for Weed and Crop Management	2+1=3
MICRO 505*	Soil microbiology	2+1=3
MICRO 511	Biofertilizer technology	2+1=3
PP 501*	Principles of Plant Physiology-I: Plant Water Relations	2+1=3
PP 508	Physiology of Field Crops	2+0=2
PP 510*	Seed Physiology	2+1=3
PP 512	Crop Growth Regulation and Management	2+0=2
OF 503	Organic Crop Production Systems	2+1=3
OF 504	Plant Health Management	2+1=3
OF 506	Farming systems suitable for organic managements	2+1=3
OF 511	Organic Input Management and Production Technologies	2+1=3

Compulsory Non Credit Deficiency Courses
(those who are non B.Sc.(Hon) Agriculture Graduates)

Course Code	Semester	Course Title	Credit Hrs.
AGRON 411	I	Fundamentals of Agronomy	2 (1+1)
AGRON 412	I	Farming System and Sustainable Agriculture	1 (1+0)
AGRON 413	I	Crop Production Technology-II (Rabi crops)	2 (1+1)
AGRON 424	II	Crop Production Technology-I (Kharif crops)	2 (1+1)
AGRON 425	II	RainfedAgriculture and Watershed Management	2 (1+1)
		Total	**9 (5+4)**

Students from Forestry and Horticulture stream will be required to completed Non credit deficiency courses (6 to 9credits) from the above courses related to the discipline in which admitted and as decided by the Student Advisory Committee.

Course and Credit Requirement
M.Sc. (Agri) Agronomy
Course Structure

1. M.Sc. (Agriculture) Agronomy

CourseNo	Credithour	Coursetitle
AGRON 501*	3+0 = 3	Modern Concepts in Crop Production
AGRON502*	2+1=3	Principles and practices of soil fertility and nutrient management
AGRON 503*	2+1 = 3	Principles and Practices of Weed Management
AGRON 504*	2+1 = 3	Principles and Practices of Water Management
AGRON 505	1+1 = 2	Conservation Agriculture
AGRON 506	2+0 = 2	Agronomy of major Cereals and Pulses
AGRON 507	2+1=3	Agronomy of oilseed, fibre and sugar crops
AGRON 508	2+1=3	Agronomy of medicinal, aromatic & underutilized crops
AGRON 509	2+1=3	Agronomy of fodder and forage crops
AGRON 510	2+1=3	Agrostology and Agro- Forestry
AGRON 511	2+0=2	Cropping System and Sustainable Agriculture
AGRON 512	2+1=2	Dryland Farming and Watershed Management
AGRON 513	2+1=3	Principles and practices of organic farming
AGRON 591	(1+0) 1	Master's Seminar
AGRON 599	(30)	Master's research

***Compulsory Courses**
Semester wise Core Courses offered based on credit requirement

Course Code	Semester	Course Title	Credit Hrs.
AGRON 501*	I	Modern Concepts in Crop Production	3+0=**3**
AGRON 503*	I	Principles and Practices of Weed Management	2+1 =**3**
AGRON 513	I	Principles and practices of organic farming	2+1 = **3**
AGRON 502*	II	Principles and practices of soil fertility and nutrient management	2+1 = **3**
AGRON 504*	II	Principles and Practices of Water Management	2+1 = **3**
AGRON 505	II	Conservation Agriculture	1+1 = **2**
AGRON 511	III	Cropping System and Sustainable Agriculture	2+0=**2**
AGRON 512	III	Dryland Farming and Watershed Management	2+1 = **3**
AGRON 591	IV	Master's Seminar	1+0 =**1**
		Total	**17+6=23**
AGRON 599		Master's Research	0+30 = **30**

Ph.D. (Agriculture) Agronomy
Course Structure

Course No.	Credit hour	Course title
AGRON 601*	3+0	Current trends in Agronomy
AGRON 602	2+1	Recent trends in crop growth and productivity
AGRON 603	2+1	Irrigation management
AGRON 604	2+0	Recent trends in weed management
AGRON 605	2+0	Integrated farming systems for sustainable Agriculture
AGRON 606	2+1	Soil Conservation and Watershed Management
AGRON 607	2+1	Stress Crop Production
AGRON 608*	2+0	Research and Publication ethics
AGRON-691	1+0	Doctor’s Seminar
AGRON-692	1+0	Doctor’s Seminar
AGRON-699	(75)	Doctors research

***Indicates Compulsory courses**

Semester wise core courses offered based on credit requirement
Ph. D. (Agriculture) Agronomy

Course Code	Semester	Course Title	Credit Hrs.
AGRON 601*	I	Current trends in Agronomy	3+0=**3**
AGRON 604	I	Recent trends in weed management	2+0 =**2**
AGRON 603	II	Irrigation management	2+1 =**3**
AGRON 605	II	Integrated farming systems for sustainable Agriculture	2+0 =**2**
AGRON 607	II	Stress Crop Production **(Supporting)**	2+1 =**3**
AGRON 608*	III	Research and Publication ethics	2+0=**2**
AGRON 602	III	Recent trends in crop growth and productivity **(Supporting)**	2+1 =**3**
AGRON 691	III	Doctoral Seminar	1+0 =**1**
AGRON 692	IV	Doctoral Seminar	1+0 =**1**
		Total	**17+3 =20**
		Doctoral Research	**0+75 = 75**

***Compulsory Courses**

Optional Courses for Ph.D. (Agriculture) Agronomy :

Course Code	Semester	Course Title	Credit Hrs.
STAT 601	II	Bioinformatics	2+0=2
STAT 602	I	Experimental Designs	2+1=3

Minor Disciplines:

1. Natural Resource Management
2. Seed Science and Technology
3. Plant Physiology
4. Soil Science
5. Agricultural Meteorology
6. Plant Protection
7. Microbiology
8. Organic Farming
9. Agricultural Chemicals
10. Forestry

Suggestive minor or supporting courses:

Course Code	Course Title	Credit Hrs.
AGRON 602	Recent trends in crop growth and productivity	2+1 =3
AGRON 607	Stress Crop Production	2+1 =3
AGM 601*	Climate Change and Sustainable Development	2+1=3
SOIL 603*	Physical chemistry of soil	2+0=2
SOIL 602	Modern concept in soil fertility	2+0=2
SOIL 604*	Soil genesis and micro morphology	2+0=2
SOIL606	Soil resource management	3+0=3
SOIL 609	Recent trends in soil microbial biodiversity	2+1=3
AC 601*	Agrochemical Formulation Technology	2+2=4
AC 604	Pesticide Metabolism, Persistence, and Decontamination	2+1=3
MICRO 603*	Recent development in soil microbiology	2+0=2
MICRO 605*	Plant microbe interactions	2+1=3
PP 606	Global Climate Change and Crop Response	2+0=2
PP 609	Plant-microbe Interactions	2+1=3
PP 610	Weed Biology and Physiology of Herbicide Action	2+0=2

Course Contents
M.Sc. (Agriculture) Agronomy

AGRON 501

Credit Hour: 3+0

Course title: MODERN CONCEPTS IN CROP PRODUCTION

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

Theory

UNIT-I:
Crop growth analysis in relation to environment; agro-ecological zones of India.

UNIT-II:
Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.
UNIT-III:
Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modelling for desired crop yield, Define; causes; factors and remedies of lodging.
UNIT-IV:
Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition; Remedies to mitigate environmental stress.
UNIT-V:
Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponics, Hydroponics, Robotics and terrace farming. use of GIS, GPS and remote sensing in modern agriculture and protected agriculture, use of Drone technology in modern agriculture; Vertical farming.
Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and class discussion
Learning outcome: Basic knowledge on soil management and crop production

Reading materials:

Balasubramaniyan P &Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.

Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
Paroda R.S. 2003. *Sustaining our Food Security*. Konark Publ.
Reddy SR. 2000. *Principles of Crop Production*. Kalyani Publ.

Sankaran S &Muda liar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
Alvin, P.T. and Kozlowski, T.T. (ed.) 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
Gardner, P.P., Pearce, G.R. and Mitchell, R. L. 1985. *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
Lal, R. 1989. *Conservation tillage for sustainable agriculture:* Tropicsversus Temperate Environments. Advances in Agronomy 42: 85-197.
Wilsie, C.P. 1961. Crop Adaptation and Distribution. Euresia Pub., New Delhi.
Rana D.S., P.K. Ghosh, Y.S. Shivay, Gurbachan Singh (2016 Ed) *Modern Concepts of Agronomy* ISA, New Delhi Publ.
K.R. Krishna (2021 Ed) *Precision Farming Soil Fertility and Productivity Aspects*, CRC Press Publ.
All about Drone 2015 by Ronald Sanford

Lecture Schedule:
Theory

S No	Topic	No. of Lecture (s)
1.	Crop growth analysis in relation to environment;	03
2.	Agro-ecological zones of India.	01
3.	Quantitative agro-biological principles and Inverse yield nitrogen law;	02
4.	Mitscherlich yield equation, its interpretation and applicability; Bauleunit.	01
5.	Effect of lodging in cereals;	03
6.	Physiology of grain yield in cereals;	02
7.	Optimization of plant population and planting geometry in relation to different resources,	01
8.	Concept of ideal plant type	01
9.	Crop modelling for desired crop yield	02
10.	Define; causes; factors and remedies of lodging	02
11.	Scientific principles of crop production;	02
12.	Crop response production functions;	02
13.	Concept of soil plant relations;	02
14.	Yield and environmental stress,.	01
15.	Use of growth hormones and regulators for better adaptation in stressed condition; Remedies to mitigate environmental stress	02
16.	Integrated farming systems,	01
17.	Organic farming	02
18.	Resource conservation technology including modern concept of tillage;	02
19.	Dry farming;	01
20.	Determining the nutrient needs for yield potentiality of crop plants,	02

21.	Concept of balance nutrition and integrated nutrient management;	02
22.	Precision agriculture.	02
23.	Modern crop production concepts: soil less cultivation, Aeroponics, Hydroponics, Robotics and terrace farming.	02
24.	Use of GIS, GPS and remote sensing in modern agriculture and protected griculture, use of Drone technology in modern agriculture;	02
25.	Vertical farming.	01
	Total	**46**

AGRON 502

Credit hour: 2+1

Course Title: PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT

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

Theory

UNIT I
Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; Integrated Nutrient Management.

UNIT II
Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients, Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; Nutrient sources.

UNIT III
Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation, Enrichment of FYM and compost, recycling of urban waste and garbage

UNIT IV
Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; nano-fertilizer materials and application; methods of increasing fertilizer use efficiency; nutrient interactions; precision nutrient management; Forms of fertilizers (Conventional and Water soluble fertilizers), Nano fertilizers, Customized slow fertilizers.

UNIT V
Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermin-compost and vermi-wash and residue wastes in crops, STCR technique.

Practical

1. Determination of soil pH and soil EC,

2. Determination of soil organic C,
3. Determination of available N, P, K and S of soil and DTPA extractable micronutrients in soil.
4. Determination of total N, P, K and S of soil,
5. Determination of total N, P, K, S in plant,
6. Computation of optimum and economic yield
7. Nutrient requirement as per soil test,
8. Use of sensors and Apps in soil fertility estimation

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Basic knowledge on soil fertility and management

Suggested Reading:

Brady NC & Weil R.R 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu. Fageria NK, Baligar VC & Jones CA. 1991. Growth and Mineral Nutrition of Field Crops.

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

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

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

Jackson, M. L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi.

Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA soil testing for Zn, Fe, Mn and Cu. Soil Sci. Amer. J. 42(10): 421-428.

Tandon, H.L.S. (1995). Methods of Soil, Plants, Water and Fertilizer Analysis, FDCO, New Delhi, 190-205.

L.L. Somani, (2016 Ed) Soil Fertility and Crop Productivity at a Glance (Vol. I), Scientific Publishers, India

Introduction to Nano Technology by Charles P Pool and Frank J Owens

Lecture Schedule:

Theory

SN	Topic	No. of Lectur e (s)
1.	Soil fertility and productivity-factors affecting;	02
2.	Features of good soil management;	02
3.	Problems of supply and availability of nutrients;	02
4.	Relation between nutrient supply and crop growth;	02

5.	Integrated Nutrient Management.	01
6.	Criteria of essentiality of nutrients; Essential plant nutrients — their functions, nutrient deficiency symptoms	01
7.	Transformation and dynamics of major plant nutrients,	03
8.	Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; Nutrient sources.	02
9.	Preparation and use of farmyard manure, compost, greenmanures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses;	01
10.	Recycling of organic wastes and residue management.	02
11.	Soilless cultivation	01
12.	Enrichment of FYM and compost, recycling of urban waste and garbage	01
13.	Commercial fertilizers; composition, relative fertilizer value and cost;	01
14.	Crop response to different nutrients,	01
15.	Residual effects and fertilizer use efficiency; agronomic, chemical and physiological, Fertilizer mixtures and grades; nano-fertilizer materials and application; methods of increasing fertilizer use efficiency	03
16.	Nutrient interactions;	01
17.	Precision nutrient management;	01
18.	Forms of fertilizers (Conventional and Water soluble fertilizers), Nano fertilizers, Customized slow fertilizers	02
19.	Time and methods of manures and fertilizers application; foliar application and its concept	01
20.	Relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management	01
21.	Use of vermin-compost and vermi-wash and residue wastes in crops,	01
22.	STCR technique	02
	Total	**34**

Practical

SN	Topic	No. of Practical (s)
1.	Determination of soil pH	01
	Determination of soil Electrical Conductivity,	01
2.	Determination of soil organic carbon	01
3.	Determination of available N from soil	01
4.	Determination of available P from soil	01
5.	Determination of available K from soil	01
6.	Determination of available S from soil	01
7.	Determination of DTPA extractable micronutrients from soil	01
8.	Determination of total N from soil	01
9.	Determination of total P from soil	01
10.	Determination of total K from soil	01
11.	Determination of total S from soil	01
12.	Determination of total N from plant,	01

13.	Determination of total P from plant	01
14.	Determination of total K from plant	01
15.	Determination of total S from plant	01
16.	Computation of optimum and economic yield	01
17.	Nutrient requirement as per soil test,	01
18.	Use of sensors and Apps in soil fertility estimation	01
	Total	**18**

AGRON 503

Credit hour: 2+1

Course Title: PRINCIPLES AND PRACTICES OF WEED MANAGEMENT

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

Theory:

UNIT I

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and management; weed indices, weed shift in different eco-systems, weed dispersal; weed uses.

UNIT II

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

UNIT III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio- agents, and allele chemicals; movement / fate of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

UNIT IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

UNIT V

Integrated weed management; recent development in weed management- robotics, use of drones and aero planes, etc., cost: benefit analysis of weed management.

Practical

1. Identification of important weeds of different crops,

2. Preparation of a weed herbarium,

3. Weed survey in crops and cropping systems,

4. Crop-weed competition studies,

5. Weed indices calculation and interpretation with data,

6. Preparation of spray solutions of herbicides for high and low-volume sprayers,

7. Use of various types of spray pumps and nozzles and calculation of swath width,

8. Economics of weed control,

9. Herbicide resistance analysis in plant and soil,

10. Bioassay of herbicide resistance residues,

11. Calculation of herbicide requirement,

12. Effect of herbicides on soil micro flora,

113. Use of drone for herbicide application.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, field visit to identify weeds.

Learning outcome: Basic knowledge on weed identification and control for crop production

Reading materials:

Zimdahl R. L., (ed). 2018. Integrated Weed Management for Sustainable Agriculture, B.D. Sci. Pub.

Jugulan, Mithila, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press

Das T K. 2015. Weed Science: Basics and Applications, Jain Brothers (New Delhi).

Chauhan Bhagirath and Mahajan Gulshan. 2014. Recent Advances in Weed

Management. Springer.

Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.

Monaco, T. J. Weller, S. C. & Ashton, F. M. 2014. Weed Science Principles and Practices, Wiley

Gupta, O. P. 2007. Weed Management: Principles and Practices, 2nd Ed.

Walia US. 2014. Weed Management, 4th Edition Reprinted, 2016, Kalyani publisher.

Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.

Powles, S. B. and Shaner, D. L. 2001. Herbicide Resistance and World Grains, CRC Press.

Lecture Schedule:

Theory

SN	Topic	No. of Lecture (s)
1.	Weed biology, and ecology and	01
2.	classification	01
3.	Crop-weed competition including gallelopathy	01
4.	Principles and methods of weed control and management	01
5.	Weed indices, weed shifting different eco-systems	01
6.	Weed dispersal; weed uses	01
7.	Herbicide's introduction and history of the development	01
8.	Classification based on chemical, physiological application and selectivity	02
9.	Mode and mechanism of action of herbicides	02
10.	Herbicide structure - activity relationship;	02
11.	Factors affecting the efficiency of herbicides;	01
	herbicide formulations	01
12.	Herbicide mixtures, sequential application of herbicides, rotation	01
13.	Weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allele chemicals	01
14.	Movement / fate of herbicides in soil and plant	01
15.	Degradation of herbicides in soil and plants	02
16.	Herbicide resistance, residue ,persistence and management	01
17.	Development of herbicide resistance in weeds and crops	01
18.	Herbicide combination and rotation	01
19	Weed management in major crops and cropping systems	02
20	Alien, invasive and parasitic weeds and their management	02
21	Weed shifts in cropping systems	01
22	Aquatic and perennial weed control ; weed control in non-crop area	01
23	Integrated weed management	01
24	Recent development in weed management- robotics, use of drones and aero planes ,etc.	01
25.	Cost:benefit analysis of weed management.	01
	Total	**32**

Practical

SN	Topic	No. of Practical (s)
1.	Identification of important weeds of different crops	02
2.	Preparation of a weed herbarium	01
3.	Weed survey in crops and cropping systems	02
4.	Crop-weed competition studies	01

5.	Weed indices calculation and interpretation with data	01
6.	Preparation of spray solutions of herbicides for high and low-volume sprayers	01
7.	Use of various types of spray pumps and nozzles and calculation of swath width	02
8.	Economics of weed control	01
9.	Herbicide resistance analysis in plant and soil	01
10.	Bioassay of herbicide resistance residues	01
11.	Calculation of herbicide requirement	01
12.	Effect of herbicides on soil micro flora	01
13.	Use of drone for herbicide application	01
	Total	**16**

AGRON 504

Credit.hr.:2+1

Course Title: PRINCIPLES AND PRACTICES OF WATER MANAGEMENT

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

UNIT I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

UNIT II

Field water cycle, water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and losses, Soil water potentials; Kinds of water**.**

UNIT III

Soil, plant and meteorological factors determining water needs of crops, consumptive use of water; scheduling, depth and methods of irrigation; micro irrigation systems; automated irrigation system; deficit irrigation; fertigation; management of water in controlled environments, polyhouses and Hydroponics.

UNIT IV

Water management of crop and cropping system; crop water requirement; estimation of ET and effective rainfall; irrigation efficiency and water use efficiency', Water management of the major crops under climate change scenario, Virtual Water.

UNIT V

Excess of soil water and plant growth;, drainage requirement of crops and methods of field drainage, their layout and spacing;

UNIT VI

Quality of irrigation water and management of saline water for irrigation, water management in problem soils

UNIT VII

Soil moisture conservation, conjunctive water uses; water harvesting; roof-water harvesting; rain water management and its utilization for crop production.

Practical

1. Determination of Field capacity by field method
2. Determination of Permanent Wilting Point by sunflower pot culture technique
3. Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
4. Determination of Hygroscopic Coefficient
5. Determination of maximum water holding capacity of soil
6. Measurement of matric potential using gauge and mercury type tensiometer
7. Determination of soil-moisture characteristics curves
8. Determination of saturated hydraulic conductivity by constant and falling head method
9. Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
10. Measurement of soil water diffusivity
11. Estimation of unsaturated hydraulic conductivity
12. Estimation of upward flux of water using tensiometer and from depth ground water table
13. Determination of irrigation requirement of crops (calculations)
14. Determination of effective rainfall (calculations)
15. Determination of ET of crops by soil moisture depletion method
16. Determination of water requirements of crops
17. Measurement of irrigation water by volume and velocity-area method
18. Measurement of irrigation water by measuring devices and calculation of Irrigation efficiency
19. Determination of infiltration rate by double ring in filtrometer
20. Use of different apps for irrigation and fertigation scheduling
21. Estimation of Potential ET by Thornthwaite method

22. Estimation of uniformity coefficient of pressurized irrigation system.

23. Artificial intelligence and machine learning in irrigation management

24. Estimation of Reference ET by Penman Monteith Method

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome: Basic knowledge on water management for optimization of crop yield

Reading materials:

Majumdar D.K. 2014. Irrigation Water Management: Principles and Practice.PHL Learning private publishers

Mukund Joshi. 2013.A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers

Lenka D. 1999. Irrigation and Drainage. Kalyani.

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

Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi. Panda SC. 2003. Principles and Practices of Water Management. Agrobios.

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

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

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

Lecture Schedule:

Theory

S N	Topic	No. of Lecture (s)
1	Water and its role in plants	01
2	Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state	01
3	Major irrigation projects, extent of area and crops irrigated in India and indifferent states.	01
4	Field water cycle	01
	Kinds of water, Water movement in soil and plants	01
5	Transpiration; soil-water-plantrelation ships	01
6	Water absorption by plants	01
7	Plant response to water stress	01
8	Crop plant adaptation to moisture stress condition	01
9	Water availability and its relationship with nutrient	01

	availability and losses	
10	Soil, plant and meteorological factors determining water needs of crops	01
11	Consumptive use of water; scheduling, depth and methods of irrigation	02
	Micro irrigation systems; automated irrigation system; deficit irrigation; fertigation	01
12	Management of water in controlled environments, polyhouses and Hydroponics	02
13	Water management of crop and cropping system	02
14	Crop water requirement; estimation of ET and effective rainfall	01
15	Irrigation efficiency and water use efficiency’	01
16	Water management of the major crops under climate change scenario	01
17	Virtual Water	01
18	Excess of soil water and plant growth	01
19	Drainage requirement of crops and methods of field drainage, their layout and spacing	02
20	Quality of irrigation water and management of saline water for irrigation	02
21	Water management in problem soils	01
22	Soil moisture conservation	01
23	Conjunctive water uses; water harvesting; roof-water harvesting	01
24	Rain water management and its utilization for crop production.	02
	Total	**32**

Practical

SN	Topic	No. of Practical (s)
1	Determination of Field capacity by field method Determination of Permanent Wilting Point by sunflower pot culture technique	01
2	Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus	01
3	Determination of Hygroscopic Coefficient Determination of maximum water holding capacity of soil	01
4	Measurement of matric potential using gauge and mercury Type tensiometer	01
5	Determination of soil-moisture characteristics curves	01
6	Determination of saturated hydraulic conductivity by constant and falling head method	01
7	Determination of hydraulic conductivity of saturated soil below the water table by auger hole method	01
8	Measurement of soil water diffusivity Estimation of unsaturated hydraulic conductivity	01
9	Estimation of upward flux of water using tensiometer and from depth ground water table	01
10	Determination of irrigation requirement of crops (calculations) Determination of effective rainfall (calculations)	01
11	Determination of ET of crops by soil moisture depletion method Determination of water requirements of crops	01
12	Measurement of irrigation water by volume and velocity area method	01

	Measurement of irrigation water by measuring devices and calculation of irrigation efficiency	
13	Determination of infiltration rate by double ring infiltrometer	01
14	Use of different apps for irrigation and fertigation scheduling	01
15	Estimation of Potential ET by Thornthwaite method Estimation of Reference ET by Penman Monteith Method	01
16	Estimation of uniformity coefficient of pressurized irrigation system Artificial intelligence and machine learning in irrigation management	01
	Total	**16**

AGRON 505

Credit Hour: 1+1

Course Title: Conservation Agriculture

Objective: To impart knowledge of conservation of agriculture for economic development.

Theory:

UNIT I

Conservation agriculture (CA), definition, scope, principles, prospects and importance, advantages and disadvantages; conventional and conservation agriculture systems, sustainability concerns; conservation agriculture – concept, historical background, global experiences, present status in India; similarity/dissimilarity between resource conservation technology (RCT) and CA; similarity/dissimilarity between conservation tillage and CA; modern concept of tillage and its management through conservation agriculture.

UNIT II

Crop establishment and varietal response; nutrient management; water management; weed dynamics and management; energy use, resource-and input-use efficiency; insect-pest and disease dynamics and management; farm machinery, crop residue management; constraints in crop residue management; cover crop management in CA; cropping pattern in CA, role of farm mechanization in CA

UNIT III

Climate change adaptation and mitigation potential of CA and potential benefits; C-sequestration; soil health management: physical, chemical and biological properties of soil under CA.

UNIT IV

CA in agroforestry systems, rainfed / dryland regions

UNIT V

Economic considerations in adoption of CA, constraints and future of agriculture under CA, Policy issues**.**

Practical:

1. Study of long-term experiments on CA,

2. Evaluation of soil health parameters,

3. Estimation of C-sequestration,

4. Machinery calibration for sowing different crops,

5. Weed seedbank estimation under CA,

6. Energy requirements in CA,

7. Economic analysis of CA.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome: Experience on the knowledge of various types of conservation of agriculture.

Suggested Reading:

Muhammad, F. and Kamdambot, H.M.S. (2014). Conservation Agriculture. Publisher: Springer Cham Heidelberg, New Yaork Dordrecht London. Doi: 10.1007/978-3-319-11620-4.

Bisht, J.K., Meena, V.S., Mishra, P.K. and Pattanayak, A. (2016). Conservation Agriculture- An approach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi: 10/1007/978-981-10-2558-7.

Gracia-Torres, L., Benites, J., Martinez-Vilela, A. and Holgado-Cabera, A. (2003). Conservation Agriculture- Environment Farmers experiences, innovations Socio- economic policy.

Arakeri HR & Roy D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.

Dhruvanarayana VV. 1993. Soil and Water Conservation Research in India. ICAR.

FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.

Yellamanda Reddy T &Sankara Reddy GH. 1992. Principles of Agronomy. Kalyani.

Conservation Agriculture by M. C. Hugh 2010

V.K. Singh & B. Gangwar. 2018, System based conservation Agriculture

Lecture Schedule:

Theory

Lecture No.	Topic	Weightage (%)
UNIT I		
1 & 2	Conservation Agriculture (CA), definition, scope, principles, prospects and importance, advantages and disadvantages	10
3 & 4	Conventional and conservation agriculture systems, sustainability concerns; conservation agriculture – concept, historical background, global experiences, present status in India	12
5 & 6.	Similarity/dissimilarity between resource conservation technology (RCT) and CA; similarity/dissimilarity between conservation tillage and CA; modern concept of tillage and its management through conservation agriculture	12
UNIT II		
7.	Crop establishment and varietal response; nutrient management; water management; weed dynamics and management	10
8.	Energy use, resource-and input-use efficiency; insect-pest and disease dynamics and management; farm machinery	9
9.	Crop residue management; constraints in crop residue management; cover crop management in CA; cropping pattern in CA, role of farm mechanization in CA	10
UNIT III		
10 &11.	Climate change adaptation and mitigation potential of CA and potential benefits	9
12 &13.	C-sequestration; soil health management: physical, chemical and biological properties of soil under CA.	10
UNIT IV		
14.	CA in agroforestry systems rainfed/ dryland regions	8
UNIT V		
15 &16.	Economic considerations in adoption of CA, constraints and future of agriculture under CA, Policy issues	10

Practice

Practical No.	Topic
1 to 3	Study of long-term experiments on Conservation Agriculture
4 to 6.	Evaluation of soil health parameters

7 to 9.	Estimation of Carbon sequestration
10 to 11	Machinery calibration for sowing different crops
12 to 13	Weed seed bank estimation underConservation Agriculture
14	Energy requirements in Conservation Agriculture
15 to 16.	Economic analysis of Conservation Agriculture

AGRON 506:

Credit Hr: 2+0

Course Title: AGRONOMY OF MAJOR CEREALS AND PULSES

Objective: To impart knowledge of crop husbandry of cereals and pulse crops.

Theory

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

UNIT-I:

Rabi cereals: Wheat, Sorghum

UNIT-II:

Kharif cereals: Rice, maize, sorghum, pearl millet, small millets/ nutria millets viz., Finger millet, Foxtail millet, little millet, Barnyard millet, Proso millet, Kodo millet.

UNIT-III:

Rabi pulses: Chickpea, lentil, field peas, French bean

UNIT-IV:

Kharif pulses: Pigeon pea, green gram, Black gram, cowpea, kidney bean

Practical

1. Phenological studies at different growth stages of crop

2. Estimation of crop yield on the basis of yield attributes

3. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

4. Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)

5. Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ratio, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)

6. Estimation of protein content in pulses

7. Judging of physiological maturity in different crops

8. Intercultural operations in different crops

9. Determination of cost of cultivation of different crops

10. Working out harvest index of various crops

11. Study of seed production techniques in selected crops

12. Visit of field experiments on cultural, fertilizer, weed control and water management aspects

13. Visit to nearby villages for identification of constraints in crop production

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Basic knowledge on cereals and pulse growing in the country.

Reading materials:

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

Hunsigi G & Krishna KR. 1998. Science of Field Crop Production. Oxford& IBH. Jeswani LM &Baldev B. 1997. Advances in Pulse Production Technology. ICAR. Khare D &Bhale MS. 2000. Seed Technology. Scientific Publ.

Kumar Ranjeet& Singh NP. 2003. Maize Production in India: Golden Grain in Transition. IARI, New Delhi.

Pal M, Deka J & Rai RK. 1996. Fundamentals of Cereal Crop Production. Tata McGraw Hill.

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

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

Singh, SS. 1998. Crop Management. Kalyani. Yadav DS. 1992. Pulse Crops. Kalyani.

Walia U S, Walia S S, Kler D S and Dalip Singh. 2011. Science of Agronomy. Scientific Publishers (India)

Lecture Schedule:

Theory

Lecture No.	**Topic**	**Weightage (%)**
UNIT I	***Rabi* cereals**	
	Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and	

	cultural requirements, nutrition, weed management; quality components, handling and processing of the produce for maximum production of …..	
1 & 2.	Wheat	10
3 &4.	Sorghum	8
UNIT II	***Kharif* cereals**	
5, 6 & 7.	Rice	10
8 & 9.	Maize	7
10.	Sorghum	7
11.	Pearl millet	6
12,13 & 14	Small millets/nutria millets *viz*., Finger millet, Foxtail millet, little millet, Barnyard millet, Proso millet, Kodo millet	8
UNIT III	***Rabi* pulses**	
15.	Chickpea	7
16 & 17.	Lentil, field peas, French bean	8
UNIT IV	***Kharif* pulses**:	
18.	Pigeon pea	6
19.	Green gram	6
20.	Black gram	6
21.	Cowpea	6
22.	Kidney bean/Moth bean	5

AGRON 507

Credit Hour: 2+1

Course Title: AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS

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

Theory

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

UNIT I

Rabi oilseeds – Rapeseed and mustard, Linseed, Niger and Safflower

UNIT II

Kharif oilseeds - Groundnut, Sesame, Castor, Sunflower and Soybean

UNIT III

Fiber crops - Cotton, Jute, Ramie and Mesta.

UNIT IV

Sugar crops – Sugar-beet and Sugarcane.

Practical

1. Planning and layout of field experiments

2. Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane

3. Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop

4. Intercultural operations in different crops

5. Cotton seed treatment

6. Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)

7. Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ratio, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)

8. Judging of physiological maturity in different crops and working out harvest index

9. Working out cost of cultivation of different crops

10. Estimation of crop yield on the basis of yield attributes

11. Formulation of cropping schemes for various farm sizes and calculation of

cropping and rotational intensities

12. Determination of oil content in oilseeds and computation of oil yield

13. Estimation of quality of fiber of different fiber crops

14. Study of seed production techniques in various crops

15. Visit of field experiments on cultural, fertilizer, weed control and water management aspects

16. Visit to nearby villages for identification of constraints in crop production

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome: Basic knowledge on production of oil seed, sugar and fibre crops.

Suggested Reading:

Das NR. 2007. Introduction to Crops of India. Scientific Publ.
Das PC. 1997. Oilseed Crops of India. Kalyani. Lakshmikantam N. 1983. Technology in Sugarcane Growing. 2nd Ed. Oxford & IBH.
Prasad, Rajendra. 2002. Text Book of Field Crop Production. ICAR.
Singh C, Singh P & Singh R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
Singh SS. 1998. Crop Management. Kalyani.

Lecture Schedule:

Theory

Lecture No.	Topic	Weightage (%)
UNIT I	***Rabi* Oil seeds**	
	Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, weed management; quality components, handling and processing of the produce for maximum production of …..	
1 & 2.	Rapeseed and mustard	8

3.	Linseed	7
4.	Niger	7
5.	Safflower	7
UNIT II	***Kharif* Oil seeds**	
6 & 7.	Groundnut	8
8.	Sesame	7
9.	Castor	6
10.	Sunflower	6
11.	Soybean	6
UNIT III	**Fiber crops**	
12 to 13.	Cotton	6
14.	Jute	6
15.	Ramie	6
16.	Mesta	6
UNIT IV	**Sugar crops**	
17.	Sugar-beet	6
18&20.	Sugarcane.	8

Practical

Practical No.	**Topic**
1.	Planning and layout of field experiments
2.	Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
3	Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice, phenological studies at different growth stages of crop
4.	Intercultural operations in different crops

5.	Cotton seed treatment
6.	Working out growth indices (CGR, RGR, NAR LAI, LAD, LAR, LWR, SLA, SLW etc.)
7.	Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc.)
8.	Judging of physiological maturity in different crops and working out harvest index
9.	Working out cost of cultivation of different crops
10.	Estimation of crop yield on the basis of yield attributes
11.	Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
12.	Determination of oil content in oil seeds and computation of oil yield
13.	Estimation of quality of fiber of different fiber crops
14.	Study of seed production techniques in various crops
15.	Visit of field experiments on cultural, fertilizer, weed control and water management aspects
16.	Visit to near by villages for identification of constraints in crop production

AGRON 508 / PSMA 503

Credit hour: 2+1

Course Title: AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED CROPS

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

Theory

UNIT-I:

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

UNIT-II:

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (*Mulhati, Isabgol, Rauwolfia*, *Poppy*, *Aloevera, Satavar*, *Stevia*, *SafedMusli*, *Kalmegh, Asaphoetida, Nuxvomica*, *Rosadle*, *Asalio* etc.).

UNIT-III:

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

UNIT-IV:

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

UNIT-V:

Post harvest handling –drawing, processing, grading, packing and storage, value addition and quality standards in herbal products, diversification options with medicinal, aromatic and under-utilized crops.

Practical

1. Identification of crops based on morphological and seed characteristics

2. Raising of herbarium of medicinal, aromatic and under-utilized plants

3. Quality characters in medicinal and aromatic plants

4. Methods of analysis of essential oil and other chemicals of importance in medicinal

and aromatic plants.

5. Indigenous techniques of Value addition in Medicinal plants

6. Methods of Oil extraction from Aromatic plants

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome: acquainted with various MAP and their commercial base for developing entrepreneurship.

Suggested Reading:

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

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

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

Bisht A. S. (2019 Ed) Hand Book of Medicinal and Aromatic Plants. Brillion Publishing House, New Delhi

Hussain A. 1984. Essential Oil Plants and their Cultivation. CIMAP, Lucknow. Hussain A. 1993. Medicinal Plants and their Cultivation. CIMAP, Lucknow.

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

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

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

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

Lecture Schedule:

Theory

Lecture No.	Topic to be covered
1	Importance of medicinal and aromatic plants in human health, national economy and related industries.
2	Classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

3	Climate and soil requirements; cultural practices; yield and important constituents of Mulhati.
4	Climate and soil requirements; cultural practices; yield and important constituents of Isabgol.
5	Climate and soil requirements; cultural practices; yield and important constituents of Rauwolfia.
6	Climate and soil requirements; cultural practices; yield and important constituents of Poppy.
7	Climate and soil requirements; cultural practices; yield and important constituents of *Aloevera* and Satavar.
8	Climate and soil requirements; cultural practices; yield and important constituents of Stevia.
9	Climate and soil requirements; cultural practices; yield and important constituents of Safed Musli.
10	Climate and soil requirements; cultural practices; yield and important constituents of Kalmegh.
11	Climate and soil requirements; cultural practices; yield and important constituents of Asaphoetida.
12-13	Climate and soil requirements; cultural practices; yield and important constituents of *Nuxvomica*, Rosadle and Asalio.
14-15	Climate and soil requirements; cultural practices; yield and important constituents of Citronella and Palmarosa.
16-17	Climate and soil requirements; cultural practices; yield and important constituents of Mentha and Basil.
18-19	Climate and soil requirements; cultural practices; yieldand important constituents of Lemon grass and Rose.
20-21	Climate and soil requirements; cultural practices; yieldand important constituents of Patchouli, Geranium and Vetiver.
22-23	Climate and soil requirements; cultural practices; yield of under-utilized crops viz. Ricebean and Lathyrus
24-25	Climate and soil requirements; cultural practices; yield of under-utilized crops viz. Sesbania and Clusterbean
26-27	Climate and soil requirements; cultural practices; yield of under-utilized crops viz. French bean andFenugreek
28-30	Climate and soil requirements; cultural practices; yield of under-utilized crops viz. Grain Amaranth, Coffee and Tea
31	Climate and soil requirements; cultural practices; yield of under-utilized crop viz. Tobacco.
32-33	Post harvest handling –drawing, processing, grading, packing and storage, value addition and quality standard sin herbal products.
34	Diversification options with medicinal, aromatic and under-utilized crops.

Practical

Exercise No.	Title of the exercise
1-2	Identification of crops based on morphological an seed characteristics
3-4	Raising of herbarium of medicinal, aromatic and under-utilized plants
5-6	Quality characters in medicinal and aromatic plants
7-9	Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.
10-11	Indigenous techniques of Value addition in Medicinal plants
12-14	Methods of Oil extraction from Aromatic plants

AGRON 509

Cr Hr: 2+1

Course Title: AGRONOMY OF FODDER AND FORAGE CROPS

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

Theory

UNIT-I:

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

UNIT-II:

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasse slime, Napier grass, Panicum, Lasiuras, Cenchrus, Dinanath Grass. Anjan Grass, Guinea Grass. Setaria. Marval Grass, Para Grass etc.

UNIT-III:

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

UNIT-IV:

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poorquality fodder. Fodder production through hydroponics. Azolla cultivation; Introduction of new fodder crops like forage cactus, Drumstick, Khejari, Hadga etc

UNIT-V:

Economics of forage cultivation uses and seed production techniques of important fodder crops, Seed production of grasses.

Practical

1. Practical training of farm operations in raising fodder crops.

2. Canopy measurement, yield, Leaf: Stem ratio and quality estimation, viz. crude protein,

NDF, ADF, lignin, silica, cellulose and IVDMD etc. of various fodder and forage crops

3. Anti-quality components like HCN in sorghum and such factors in other crops

4. Hay and silage making and economics of their preparation.

5. Hydroponic fodder production of maize.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome: acquainted with various fodder and forage crops and their commercial base for developing entrepreneurship.

Suggested Reading:

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

Das NR. 2007. Introduction to Crops of India. Scientific Publ. Narayanan TR & Dabadghao

PM. 1972. Forage Crops of India. ICAR.

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

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

IBH.

Tejwani KG. 1994. Agroforestry in India. Oxford & IBH.

Lecture Schedule:

Theory

Lecture No.	**Topic to be covered**
1	Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum
2	Maize
3	Bajra
4	Cowpea and Oats
5	Barley
6	Berseem
7	Lucerne etc.,
8	Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses like Napier grass.
9-10	Panicum and Lasiuras
11-12	Cenchrus and Dinanath Grass.

13	Anjan Grass and Guinea Grass.
14-15	Setaria, Marval Grass and Para Grass etc.
16	Year-round fodder production and management, preservation and utilization of forage and pasture crops.
17-18	Grass land management and conservation.
19-20	Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage
21-22	Use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.
23	Fodder production through hydroponics.
24	Azolla cultivation
25-26	Introduction of new fodder crops like forage Cactus and Drumstick,
27-28	Khejari and Hadga etc
29-30	Economics of forage cultivation uses and seed production techniques of important fodder crops, Seed production of grasses.

Practical

Exercise No.	Title of the exercise
1-2	Practical training of farm operations in raising fodder crops
3-5	Canopy measurement, yield, Leaf: Stem ratio and quality estimation of various fodder and forage crops viz. crude protein and NDF
6-7	ADF, lignin and silica
8-9	Cellulose and IVDMD etc.
10-11	Anti-quality components like HCN in sorghum and such factors in other crops
12-13	Hay and silage making and economics of their preparation.
14-15	Hydroponic fodder production of maize

AGRON 510

Credits Hr: 2+1

Course Title: AGROSTOLOGY AND AGRO-FORESTRY
(To be taught jointly by Agronomy and Forestry)

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

Theory

UNIT-I:

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

UNIT-II:

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

UNIT-III:

Agroforestry: definition and importance; Agroforestry systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

UNIT-IV:

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

Practical

1. Preparation of charts and maps of India showing different types of pastures and agro-forestry systems

2. Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry

3. Seed treatment for better germination of farm vegetation

4. Methods of propagation/planting of grasses and trees in silvipastoral system

5. Fertilizer application in strip and silvipastroal systems

6. After-care of plantation

7. Estimation of protein content in loppings of important fodder trees

8. Estimation of calorie value of wood of important fuel trees

9. Estimation of total biomass and fuel wood

10. Economics of agro-forestry

11. Visit to important agro-forestry research stations

Teaching methods / activities: Classroom teaching with AV aids, group discussion, assignment and field visit

Learning outcome: Basic knowledge on agroforestry, forage crops and their utility

Suggested Reading:

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

Dabadghao PM & Shankaranarayan KA. 1973. The Grass Cover in India. ICAR.

Dwivedi AP. 1992. Agroforestry- Principles and Practices. Oxford & IBH.

Indian Society of Agronomy. 1989. Agroforestry System in India. Research and Development, New Delhi.

Narayan TR & Dabadghao PM. 1972. Forage Crop of India. ICAR, New Delhi.

Lecture Schedule

Theory

Lecture No.	Topic to be covered
1	Agrostology: definition and importance; principles of grass land ecology.
2-3	Grass land ecology— community, climax, dominant species, succession, biotype, ecological status of grass lands in India, grass cover of India; problems and management of grasslands.
4-5	Importance, classification (various criteria), scope, status and research needs of pastures.
6-8	Pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses, Agro technique for pasture land improvement and maintenance

9	Agroforestry: definition and importance
10-12	Agroforestory systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation
13-15	Crop production technology in agro-forestory and agrostology system; silvipastoral system
16	Meaning and importance for wasteland development
17-18	Selection of species, planting methods and problems of seed germination in agro-forestry systems
19-20	Irrigation and manuring in agro-forestry systems
21	Associative influence in relation toabove ground and underground interferences
22	Lopping and coppicing in agro-forestry systems
23-25	Social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

Exercise No.	Title of the exercise
1	Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
2	Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
3	Seed treatment for better germination of farm vegetation
4	Methods of propagation/ planting of grasses and trees in silvipastoral system
5	Fertilizer application in strip and silvi pastoral systems
6	After-care of plantation
7	Estimation of protein content in loppings of important fodder trees
8	Estimation of calorie value of wood of important fuel trees
9	Estimation of total biomass and fuelwood
10	Economics of agro-forestry
11	Visit to important agro-forestry research stations

AGRON 511

Cr Hr: 2+0

Course Title: CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE

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

Theory

UNIT-I:

Cropping systems: definition, indices and its importance; physical resources, resources capture and use efficiency; major cropping systems of irrigated; rainfed / dry land and semi-arid / arid environments and their approximate acreage in India; soil and water management in cropping systems; assessment of land use; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions.

UNIT-II:

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, criteria in assessing the yield advantages; mechanism of yield advantage in intercropping systems, biological and agronomic basis of yield advantage under intercropping..

UNIT-III:

Cropping systems: above and below ground interactions and allelopathic effects; competitive relationship and competition functions; cropping patterns; alternate land use and crop diversification in rainfed and irrigated conditions; multi-storied cropping and yield stability in intercropping, role of non- monetary inputs and low cost technologies; categorization of cropping systems for soil health, family nutrition, livestock nutrition and income enhancement; research need on sustainable agriculture.

UNIT-IV:
Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

UNIT-V:
Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Unit VI:
Artificial Intelligence- Concept and application.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment.

Learning outcome: Basic knowledge on cropping system for sustainable agriculture.

Suggested Reading:

Panda S. C. (2017). Cropping systems and sustainable agriculture. Agrobios (India)

Panda S. C. (2018) Cropping and farming systems. Agrobios.

Palaniappan SP & Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.

Panda SC. 2003. Cropping and Farming Systems. Agrobios.

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

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

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

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1997. Soil Fertility and Fertilizers.

Prentice Hall.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Cropping systems: definition, indices and its importance; physical resources, resources capture and use efficiency	01
2.	Major cropping systems of irrigated; rainfed / dry land and semi-arid / arid environments and their approximate acreage in India	02
3.	Soil and water management in cropping systems; assessment of land use; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions.	02
4.	Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping	01
5.	Criteria in assessing the yield advantages; mechanism of yield advantage in intercropping systems, biological and agronomic basis of yield advantage under intercropping.	03
6.	Cropping systems: above and below ground interactions and allelopathic effects; competitive relationship and competition functions; cropping patterns; alternate land use and crop diversification in rainfed and irrigated conditions	03

7.	Alternate land use and crop diversification in rainfed and irrigated conditions	02
8.	Multi-storied cropping and yield stability in intercropping, role of non- monetary inputs and low cost technologies	02
9.	Categorization of cropping systems for soil health, family nutrition, livestock nutrition and income enhancement; research need on sustainable agriculture.	02
10.	Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management	03
11.	Silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands	02
12.	Fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.	03
13.	Plant ideotypes for drylands; plant growth regulators and their role in sustainability	02
14.	Models for evaluating silvicultural alternatives	02
15.	Artificial Intelligence- Concept and application.	02
	Total	**32**

AGRON 512

Cr Hr: 2+1

Course Title: DRYLAND FARMING AND WATERSHED MANAGEMENT

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

Theory

UNIT-I:

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

UNIT-II:

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

UNIT-III:

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; management and breeding strategies to improve crop productivity under different patterns of drought situation under limited water supplies preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions; abiotic stress management in dry land agriculture

UNIT-IV:

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use; good agricultural practices in dry land; farm pond technology; tools and implements in dry land agriculture.

UNIT-V:

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

Practical

1. Method of Seed Priming

2. Determination of moisture content of germination of important dryland crops

3. Determination of Relative Water Content and Saturation Deficit of Leaf

4. Moisture stress effects and recovery behaviour of important crops

5. Estimation of Potential ET by Thornthwaite method

6. Estimation of Reference ET by Penman Monteith Method

7. Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)

8. Classification of climate by Koppen Method

9. Estimation of water balance by Thornthwaite method

10. Estimation of water balance by FAO method

11. Assessment of drought

12. Estimation of length of growing period

13. Estimation of probability of rain and crop planning for different drought condition

14. Spray of anti-transpirants and their effect on crops

15. Estimation of water use efficiency

16. Visit to dryland research stations and watershed projects

17. Drought indices in dryland Crops and Cropping pattern in dry land to mitigate drought condition

18. Study of green seeker and leaf colour chart techniques in precision nutrient management

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment.

Learning outcome: Basic knowledge on dry land farming and soil moisture conservation.

Suggested Reading:

Reddy T.Y.2018.Dryland Agriculture Principles &Practices, Kalyani publishers

Das NR. 2007. Tillage and Crop Production. Scientific Publ.

Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.

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

Gupta US. (Ed.). 1995. Production and Improvements of Crops forDrylands. Oxford & IBH.

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

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

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

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

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

Singh SD. 1998. Arid Land Irrigation and Ecological Management. Scientific Publ.

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

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Definition, concept and characteristics of dry land farming	02
2.	Dry land versus rainfed farming	01
3.	Significance and dimensions of dry land farming in Indian agriculture.	02
4.	Soil and climatic parameters with special emphasis on rainfall characteristics;	01
5.	Constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability	03
6.	Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies	03
7.	Management and breeding strategies to improve crop productivity under different patterns of drought situation under limited water supplies preparation of appropriate crop plans for dry land areas	03
8.	Mid contingent plan for aberrant weather conditions; abiotic stress management in dry land agriculture	03
9.	Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage	02

10.	Concept of conservation tillage; tillage in relation to weed control and moisture conservation	02
11.	Techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics)	02
12.	Anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use	02
13.	Good agricultural practices in dry land	01
14.	Farm pond technology; tools and implements in dry land agriculture	02
15.	Concept of watershed resource management, problems, approach and components	03
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Method of Seed Priming	1
2.	Determination of moisture content of germination of important dryland crops	1
3.	Determination of Relative Water Content and Saturation Deficit of Leaf	1
4.	Moisture stress effects and recovery behaviour of important crops	1
5.	Estimation of Potential ET by Thornthwaite method	1
6.	Estimation of Reference ET by Penman Monteith Method	1
7	Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)	1
8	Classification of climate by Koppen Method	1
9	Estimation of water balance by Thornthwaite method	1
10	Estimation of water balance by FAO method	1
11	Assessment of drought	1
12	Estimation of length of growing period	1

13	Estimation of probability of rain and crop planning for different drought condition	1
14	Spray of anti-transpirants and their effect on crops	1
15	Estimation of water use efficiency	1
16	Visit to dryland research stations and watershed projects	1
17	Drought indices in dryland Crops and Cropping pattern in dry land to mitigate drought condition	1
18	Study of green seeker and leaf colour chart techniques in precision nutrient management	1
	Total	**18**

AGRON 513

Cr Hr: 2+1

Course Title: PRINCIPLES AND PRACTICES OF ORGANIC FARMING

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

Theory

UNIT I:

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

UNIT II:

Organic farming and water use efficiency; soil fertility, nutrient recycling; organic manures, composting; soil biota and decomposition of organic residues; earthworms and vermicompost; green manures, bio-fertilizers and biogas technology; biodynamic compost, enrichment of organic manures; organic formulations and bio fertigation

UNIT III

Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity; maintenance of soil fertility, concept of IOFS; mixed cropping; cover crops; smoother crops.

UNIT IV

Pest management through biological agents and pheromones; bio-pesticides, Management of weeds; pests and diseases; Botanicals; Trap crops; Insect traps; ITKs, Bio herbicides; use of plant extract in weed management; Allelopathic effect.

UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy; types of certifications; certification agencies; branding and packaging; Farmer Participatory Organization in organic farming.

Practical

1. Compost preparation by method by aerobic and anaerobic methods

2. Methods of vermi composting

3. Identification and nursery raising of important agro-forestry tress and tress for shelter belts
4. Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field
5. Visit to a biogas plant
6. Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms
7. Preparation of different organic formulations
8. Preparation of seed album of local/ deshi germplasm
9. Visit to an organic farming research and training centre
10. Visit to NCOF

Teaching methods/activities: Classroom teaching with AV aids, group discussion, assignment. exposure visit

Learning outcome: Basic knowledge on organic farming for sustainable agriculture and development of entrepreneurship on organic inputs.

Suggested Reading:

Joshi, Mukund 2016. New Vistas of Organic Farming. Scientific Publishers

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

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

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

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

Rao BV,Venkata. 1995. Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective:

Publ.3, Parisaraprajna Parishtana, Bangalore.

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

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

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

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

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

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

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

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

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Organic farming - concept and definition, its relevance to India and global agriculture and future prospects	02
2.	Principles of organic agriculture; organic farming and sustainable agriculture;	02
3.	Selection and conversion of land, soil and water management - land use,	02
4	Conservation tillage; shelter zones, hedges, pasture management, agro-forestry.	02
5.	Organic farming and water use efficiency; soil fertility, nutrient recycling; organic manures, composting	02
6.	Soil biota and decomposition of organic residues; earthworms and vermicompost; green manures, bio-fertilizers and biogas technology;	03
7.	Biodynamic compost, enrichment of organic manures; organic formulations and bio fertigation	02
8.	Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity	03
9.	Maintenance of soil fertility, concept of IOFS; mixed cropping; cover crops; smoother crops.	03
10.	Pest management through biological agents and pheromones; bio-pesticides	02
11.	Management of weeds; pests and diseases; Botanicals; Trap crops; Insect traps; ITKs	02

12.	Bio herbicides; use of plant extract in weed management; Allelopathic effect.	01
13.	Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures	02
14.	Organic farming and national economy; types of certifications; certification agencies; branding and packaging;	02
15.	Farmer Participatory Organization in organic farming.	02
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical (s)
1.	Compost preparation by method by aerobic and anaerobic methods	3
2.	Methods of vermi-composting	2
3.	Identification and nursery raising of important agro-forestry tress and tress for shelter belts	1
4.	Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium cultures, use of Azotobacter, Azospirillum, and PSB cultures in field	3
5.	Visit to a biogas plant	1
6	Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms	1
7	Preparation of different organic formulations	2
8	Preparation of seed album of local/ deshi germplasm	1
9	Visit to an organic farming research and training centre	1
10	Visit to NCOF	1
	Total	**16**

Course Contents Doctoral Degree

AGRON 601

Credithour:3+0

CourseTitle: CURRENT TRENDS IN AGRONOMY

Objective: To acquaint the students about recent advances in agricultural production.

Theory

UNIT-I:

Agro-physiological basis of variation in yield, recent advances in soil plant-water relationship; Climate change and crop response

UNIT-II:

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming, Types of farming and their practices; Group farming; Farmer producer organizations; Micro irrigation and fertigation; Protected cultivation.

UNIT-III:

Crop residue management in multiple cropping systems; latest developments in plant management Mechanization in crop production: modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy; Mechanization in residue management; Nano fertilizers; Nano herbicides; Nano insecticides; Drone technology.

UNIT-IV:

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc., AI and machine learning, data science for agronomy

UNIT-V:

Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy. Conservation agriculture, principles, prospects and importance, potentialbenefits of CA under climate change scenario, policy issues, Constraints in CA.

Teaching methods/activities: Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome: Recent advances in agricultural production

Suggested Reading:

Agarwal RL. 1995. Seed Technology. Oxford & IBH. Dahiya BS & Rai KN. 1997. Seed Technology. Kalyani.

Govardhan V. 2000. Remote Sensing and Water Management in Command Areas: AgroecologicalProspective. IBDC.

ICAR. 2006. Hand Book of Agriculture. ICAR.

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

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

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

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

Kumar, Rajeev, Swarnkar Kumar Sushil, Singh Kumar Sunil and Narayan Sumati. 2016.AText Book of Seed Technology. Kalyani Publication.

Reddy,S.R. and Prabhakara,G.2015.Dryland Agriculture. Kalyani Publishers.

Gururajan, B. Balasubhramanian, R. and Swaminath V. 2013. Recent Strategies on Crop Production. Kalyani Publishers.

Venkateswarlu, B.and Shanker, Arun K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian journal of Agronomy 54(2):226-230.

Stuart J. Russell and Peter Norvig Artificial Intelligence A Modern Approach:

Lecture Schedule:

SN	Topic	No. of Lecture (s)
1.	Agro-physiological basis of variation in yield,	03
2.	Recent advances in soil plant-water relationship;	02
3.	Climate change and crop response	02
4.	Globalization of agriculture and WTO,	02
5.	Precision agriculture,	03
6.	Contract farming,.	01
7.	Organic farming, Marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming,	03

8.	Types of farming and their practices;	01
9.	Group farming; Farmer producer organizations;	01
10.	Micro irrigation and fertigation;	01
11.	Protected cultivation`	02
12.	Crop residue management in multiple cropping systems;	02
13.	Latest developments in plant management Mechanization in crop production:	02
14.	Modern agricultural precision tools and technologies, weed management, cropping systems, grassland management, agro-forestry, allelopathy;	03
15.	Mechanization in residue management;	02
16.	Nano fertilizers; Nano herbicides; Nano insecticides;	02
17.	Drone technology.	01
18.	GIS, GPS and remote sensing for crop management,	02
19.	Global warming,	01
20.	GM crops,	01
21.	Seed production technology; seed certification, seed multiplication, hybrid seed production etc.,	02
22.	AI and machine learning, data science for agronomy	02
23.	Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.	04
24.	Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, policy issues, Constraints in CA.	03
	Total	**48**

Course No.: AGRON 602

Credit Hour:2+1

CourseTitle:RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY

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

Theory

UNIT-I:

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

UNIT-II:

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

UNIT-III:

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

UNIT-IV:

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize; sorghum, pearl millet, pigeon pea, chickpea, cotton sugarcane etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

1. Field measurement of root-shoot relationship in crops at different growth stages

2. Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI, SLA, LWR etc. at different stages of crop growth

3. Computation of harvest index of various crops

4. Assessment of crop yield on the basis of yield attributing characters

5. Construction of crop growth curves based on growth analysis data

6. Computation of competition functions, viz., LER, IER aggressivity competition index etc. in inter cropping

7. Senescence and abscission indices

8. Analysis of productivity trend in un-irrigated areas

9. Analysis of productivity trend in irrigated areas

Teaching methods/ activities: Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome : Experience on the knowledge of crop growth for agricultural production

Suggested Reading:

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

Delvin RM & Vitham FH. 1986. Plant Physiology. CBS Publ. Evans LT.1975.Crop Physiology. Cambridge Univ. Press.

EvansLT.1996.CropEvolution, Adaptation and Yield. Cambridge Univ. Press.

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

Gupta US.1988. Progress in Crop Physiology. Oxford & IBH.

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

Mukherjee S & Ghosh AK.1996.Plant Physiology. Tata Mc Graw Hill.

Narwal S S, Politycka B & Goswami C L. 2007. Plant Physiology: Research Methods. Scientific PUB.

TiazL.and Zeiger E.2006.Plant Physiology. Sinauer Associates, Inc.

Pallaniappan S.P. and K Shivraman Cropping Systems in the Tropics: Principles and Management

Lecture Schedule:

Theory

SN	Topic	No. of Lecture (s)
1.	Plant density and crop productivity	01
2.	plant and environmental factors	01

3.	Yield, plant distribution, strategies for maximizing solar energy utilization	02
4.	Leaf area; interception of solar radiation and crop growth	02
5.	Photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis	02
6.	Difference in photosynthetic rates among and within species	02
7.	Physiological limitations to crop yield	02
8.	Solar radiation concept and agro-techniques for harvesting solar radiation	02
9.	Factors affecting light use efficiency	01
10.	Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; SLA, LWR	02
11.	Validity and limitations in interpreting crop growth and development	01
12.	Growth curves: sigmoid, polynomial and asymptotic	01
13.	Root systems; root-shoot relationship	01
14.	Principles involved in inter and mixed cropping systems under rainfed and irrigated conditions	01
15.	Concept and differentiation of inter and mixed cropping	01
16.	Criteria in assessing the yield advantages	01
17.	Competitive relationship and	01
18.	Competition functions	01
19	Biological and agronomic basis of yield advantage under intercropping	01
20	Physiological principles of dry land crop production, constraints and remedial measures constraints and remedial measures	01
21	Heat unit concept of crop maturity: concept and types of heat units.	01
22	Concept of plant ideotypes: crop physiological and new ideotypes	01
23	Characteristics of ideotype for wheat, rice, maize; sorghum, pearl millet, pigeon pea, chickpea, cotton sugarcane etc	01
24	Concept and types of growth hormones; their role in field crop production	01
25.	Efficient use of resources.	01
	Total	**32**

Practical

SN	Topic	No. of Practical (s)
1.	Field measurement of root-shoot relationship in crops at different growth stages	01
2.	Estimation of growth evaluating parameters like GR,RGR,NAR,LAI, SLA, LWR etc. at different stages of crop growth	02
3.	Computation of harvest index of various crops	02

4.	Assessment of crop yield on the basis of yield attributing characters	02
5.	Construction of crop growth curves based on growth analysis data	02
6.	Computation of competition functions, viz., LER, IER aggressively competition index etc. in inter cropping	02
7.	Senescence and abscission indices	02
8.	Analysis of productivity trend in un-irrigated areas	02
9.	Analysis of productivity trend in irrigated areas	01
	Total	**16**

AGRON 603

Credit Hour:2+1

Course Title: IRRIGATION MANAGEMENT

Objective: To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

UNIT-I

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth, role of water, quality of irrigation water.

UNIT II

Energy concept of soil water, water potential and water movement, Infiltration, soil water movement under saturated and unsaturated conditions, Poiseuille's and Darcy's law, general equation of saturated and unsaturated flow of water in soil, Soil-plant-water relationships and SPAC.

UNIT III

Concepts of evaporation, transpiration, evapotranspiration, potential and actual evapotranspiration, consumptive use, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

UNIT IV

Water requirement, irrigation needs, factors affecting irrigation need; moisture use pattern in different soils, water use efficiency, management practices for improving water use efficiency of crops. Economic analysis of irrigation and crop planning for optimum use of irrigation water.

UNIT V

Crop water stress, Water deficits and crop growth, Adaptability of crops to water stress, Crop water stress management strategies, nutrient availability in relation to soil water.

UNIT VI

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

UNIT VII

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

UNITVIII

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

Practical

1. Determination of water infiltration characteristics and water holding capacity of soil profiles.

2. Lysimetric estimation of evapotranspiration

3. Determination of crop coefficient of one important crop

4. Determination moisture extraction pattern of crops

5. Determination of consumptive use and water requirement of a given cropping pattern

6. Planning, designing and installation of drip irrigation system

7. Planning, designing and installation of sprinkler irrigation system

8. Designing of drainage channel

9. Measurement of irrigation efficiencies

10. Determination of irrigation timing under different methods of irrigation

11. Studies on sensor-based irrigation management system

12. Determination of water balance component of transplanted rice by drum culture technique

13. Visit to cooperative irrigation distribution organization

Teaching methods/activities:

Classroom teaching with AV aid, group discussion, oral presentation bystudents.

Learning outcome:

Management of irrigation water for sustainable agriculture

Reading materials:

M.P. Singh (2017). Recent advances in Irrigation water management. Kalyani Publishers

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

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

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

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

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

Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water.

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

Singh SS. 2006. Principles and Practices of Agronomy.

Lecture Schedule:

Theory

Lecture No.	Topic	Weightage(%)
UNIT I		
1& 2.	Global water resources; Water resources of India, irrigation projects during pre and post-independence period and their significance in crop production;	5
3& 4	Irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need;	6
5.	Water deficits and crop growth, role of water, quality of irrigation water	
UNIT II		
6.	Energy concept of soil water, water potential and water movement, Infiltration	5
7.	Soil water movement under saturated and unsaturated conditions	6
8&9	Poiseuille's and Darcy's law, general equation of saturated and unsaturated flow of water in soil, Soil-plant-water relationships and SPAC	6
UNIT III		
10.	Concepts of evaporation, transpiration, evapotranspiration, potential and actual evapotranspiration, consumptive use,	6
11.	Significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.	6
UNIT IV		
12& 13.	Water requirement, irrigation needs, factors affecting irrigation need; moisture use pattern in different soils,	6
14.	Water use efficiency, management practices for improving water use efficiency of crops.	6
15.	Economic analysis of irrigation and crop planning for optimum use of irrigation water.	6
UNIT V		
16.	Crop water stress, Water deficits and crop growth	5
17& 19	Adaptability of crops to water stress, Crop water stress management strategies, nutrient availability in relation to soil water	7
UNIT VI		
20& 22	Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation;	7

23.	Water quality for micro irrigation, optimizing the use of given irrigation supplies.	5
UNIT VII		
24.	Application of irrigation water, conveyance and distribution system, irrigation efficiency	5
25.	Agronomic considerations in the design and operation of irrigation projects	5
26.	Characteristics of irrigation and farming systems affecting irrigation management, water productivity	5
UNIT VIII		
27 & 28.	Land suitability for irrigation, land irrigability classification; integrated water management in command areas	5
29.	Institution of water management in commands, farmer's participation in command areas	4
30.	Role of cooperative irrigation distribution organizations, irrigation legislation	4

Practical

Practical No.	**Topic**
1.	Determination of water infiltration characteristics and water holding capacity of soil profiles
2.	Lysimetric estimation of evapotranspiration
3& 4	Determination of crop coefficient of for important crop
5.	Determination moisture extraction pattern of crops
6& 7.	Determination of consumptive use and water requirement of a given cropping pattern
8& 9.	Planning, designing and installation of drip irrigation system
10.	Planning, designing and installation of sprinkler irrigation system
11.	Designing of drainage channel
12.	Measurement of irrigation efficiencies
13.	Determination of irrigation timing under different methods of irrigation
14.	Studies on sensor-based irrigation management system
15.	Determination of water balance component of transplanted rice by drum culture technique
16.	Visit to cooperative irrigation distribution organization

AGRON 604

Credit Hour:2+0

Course Title: RECENT TRENDS IN WEED MANAGEMENT

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

UNIT I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Weed dispersal, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion– present status and factors influencing weed invasion.

UNIT II

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

UNIT III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

UNIT IV

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

UNIT V

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

UNIT VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelo chemical and allele herbicides, herbicide bioassays. Recent advances in non chemical weed management including deleterious rhizobacteria, application of Artificial intelligence, robotics, bio degradable film etc.

Teaching methods/ activities: Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning out come: Experience on the knowledge of new herbicides, the resistance, toxicity, antidotes and residue management under different cropping systems.

Suggested Readings

Zimdahl R.,(ed).2018.Integrated Weed Management for Sustainable Agriculture, B. D.Sci.Pub

Jugulan, Mithila, (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press

T. K.Das.2008.Weed Science: Basics and Applications, Jain Brothers (New Delhi) Fennimore, Steven A and Bell, Carl. 2014. Principles of Weed Control, 4thEd, California Weed Sci. Soc.

Monaco, T. J. Weller, S.C. & Ashton, F.M. 2014. Weed Science Principles and Practices, Wiley

Gupta, O.P. 2007. Weed Management: Principles and Practices, 2nd Ed.

Walia,U.S. 2010. Weed Management, Kalyani.

Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry. Springer.

Powles, S.B. and Shaner, D.L. 2001. Herbicide Resistance and World Grains, CRC Press.

Lecture Schedule:

Theory

Lecture No.	Topic	Weightage (%)
UNIT I		
1& 2.	Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects	5
3 & 4	Different methods of weed management. Weed dispersal, introduction, adaptation of weeds,	7
5& 7.	Invasive weeds – biology and management. Different mechanisms of invasion–present status and factors influencing weed invasion.	7
UNIT II		
8&9.	Physiological and biological aspects of herbicides, their absorption, translocation, metabolism	8
10& 12.	Mode of action; selectivity of herbicides and factors affecting them.	7

UNIT III		
13 & 14.	Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them	7
15.	Degradation of herbicides in soil and plants- factors affecting it,	6
16 & 17.	Primary and secondary metabolites, residue management of herbicides, adjuvants.	7
UNIT IV		
18 & 19.	Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection	8
20&22	Compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.	8
UNIT V		
23&24.	Development of transgenic herbicide resistant crops; herbicide development; registration procedures.	7
UNIT VI		
25 & 26.	Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system.	6
27&29.	Bio herbicides, allelo chemical and allele herbicides, herbicide bioassays.	7
30 & 32	Recent advances in non-chemical weed management including deleterious rhizobacteria, application of Artificial intelligence, robotics, bio degradable film etc.	10

AGRON 605

Credit Hour: 2+0

Course Title: INTEGRATED FARMING SYSTEMS AND SUSTAINABLE AGRICULTURE

Objective: To apprise about different enterprises suitable for different agro climatic conditions for sustainable agriculture.

Theory

UNIT I

Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed / irrigated condition in different land situation. farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises, Role of farming system in sustainable agriculture, advantages of IFS.

UNIT II

Concept of sustainability in of Integrated farming systems; efficient Integrated farming systems based on economic viability and natural resources-identification and management, Sustainable agriculture: definition; concept; principles; sustainable development goals.

UNIT III

Production potential of different components of Integrated farming systems; interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information. in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; components of IFS.

UNIT IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. recycling in IFS,

UNIT V

New concepts and approaches of farming system and organic farming; value addition, wastere cycling, quantification and mitigation of Green House gases; case studies / success stories of different Integrated Farming systems. cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in Integrated farming system.

Teaching methods/activities:

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome:

Experience on the knowledge of enterprises suitable for different agro climatic conditions for sustainable agriculture and their proper utilization.

Suggested Reading:

Baishya A, Borah M, Das AK, Hazarika J, Gogoi B and Borah AS 2017. Waste Recycling Through Integrated Farming systems. An Assam Agriculture Experience. Omni Scriptum Gmbh& Co. KG, Germany.

Jayanthi C. 2006. Integrated Farming systems- A way to sustainable Agriculture. Tamil Nadu Agricultural University, Coimbatore

A textbook of farming system and sustainable agriculture: by Aniket Kalhapure and Madhukar Dhonde

Edens T. (1984) Sustainable agriculture and integrated farming system. Michigan State Univ. press,

Ravisankar D.and Jayanthi C.(2015).Farming systems: concepts and approaches. Agrobios.

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

Balasubramanian P & Palaniappan SP 2006.Principles and Practices of Agronomy. Agrobios.

Joshi M & Parbhakarasetty TK. 2005.Sustainability through Organic Farming. Kalyani.

Lampin N. 1990.Organic Farming. Farming Press Books.

Palaniappan SP & Anandurai K. 1999.OrganicFarming-TheoryandPractice. Scientific Publ.

Panda SC. 2004.Cropping systems and Farming Systems. Agribios.

Gangwar B., Singh J.P., Prusty A.K, Kamta Prasad (2014),Research in farmingsystem,

Today's & Tomorrow publication

Lecture Schedule:

Theory

Lecture No.	Topics to be covered
1	Integrated Farming systems (IFS): definition, scope and importance.
2-3	Classification of IFS based on enterprises as well as under rainfed / irrigated condition in different land situation.

4-5	Farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.
6	Role of farming system in sustainable agriculture, advantages of IFS,
7	Concept of sustainability in of Integrated farming systems
8	Efficient Integrated farming systems based on economic viability.
9	Natural resources-identification and management.
10-11	Sustainable agriculture: definition, concept; principles; sustainable development goals.
12-13	Production potential of different components of Integrated farming systems.
14-16	Interaction and mechanism of different production factors; stability of Integrated Farming system based on research/long term information in different systems through research.
17	Eco-physiological approaches to intercropping.
18-19	Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; components of IFS.
20-21	Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models.
22	Evaluation of different farming systems, recycling in IFS.
23-24	New concepts and approaches of farming system and organic farming.
25	Value addition, waste re cycling.
26	Quantification and mitigation of Green House gases.
27-28	Case studies / success stories of different Integrated Farming systems.
29-30	Cropping systems and organic farming; case studies on different farming systems.
31-32	Possible use of ITK in Integrated farming system.

AGRON 606

Credit Hour:2+1

Course Title: SOIL CONSERVATION AND WATERSHED MANAGEMENT

Objective: To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Theory

UNIT-I:

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion, Causes of soil, wind and water erosion.

UNIT-II:

Soil conservation: definition, methods of soil conservation; agronomic measures-contour cultivation, stripcropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts, Intercropping, alley cropping.

UNIT-III:

Watershed management: definition, objectives, Principles, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas, management of catchment and command area, rain water harvesting, role of NGOs in watershed.

UNIT-IV:

Land use capability classification, alternate land use systems; agro-forestry; ley farming; jhum management - basic concepts, socio-ethnic aspects, its layout.

UNIT-V:

Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned jhum and measures to prevent soil erosion, factors considered in selection of drainage system, Reclamation of ill drained soils.

Practical

1. Study of different types of erosion
2. Determination of dispersion ratio
3. Estimation of soil loss by Universal Soil Loss Equation
4. Measurement of runoff and soil loss

5. Field studies of different soil conservation measures
6. Laying outrun-off plot and deciding treatments
7. Identification of different grasses and trees for soil conservation
8. Visit to watershed areas
9. Visit to a soil conservation research center, demonstration and training centre
10. Visit to Model watershed.

Teaching methods/activities:

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome:
Experience on the knowledge of soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Suggested Reading:
Arakeri HR & Roy D.1984. Principles of Soil Conservation and Water Management. Oxford & IBH.

Dhruvanarayana V V. 1993. Soil and Water Conservation Research in India.

ICAR.FAO.2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.

Frederick RT, Hobbs J, Arthur D & Roy L.1999.Soil and Water Conservation: Productivity and Environment Protection. 3rd Ed. Prentice Hall.

Gurmel Singh, Venkataraman CG, Sastry B & JoshiP. 1990. Manual of Soil and Water Conservation Practices. Oxford &IBH.

Murthy V V N. 1995.Land and Water Management Engineering.

Kalyani. Tripathi R P & Singh HP. 1993.Soil Erosion and Conservation.

Wiley Eastern. Yellamanda Reddy T & Sankara Reddy GH.1992. Principles of Agronomy. Kalyani.

Lecture Schedule

Theory

Lecture No.	Topic to be covered
1-2	Soil erosion: definition, nature and extent of erosion;
3	Types of erosion, factors affecting erosion.
4	Causes of soil, wind and water erosion

5	Soil conservation: definition, methods of soil conservation
6-7	Agronomic measures-contour cultivation, stripcropping, covercrops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices
8	Mechanical measures - bunding, gully control, bench terracing;
9-10	Role of grasses and pastures in soil conservation; wind breaks and shelter belts, Intercropping, alley cropping
11-12	Watershed management: definition, objectives, Principles,concepts, approach, components
13	Steps in implementation of watershed
14	Development of cropping systems for watershed areas
15	Management of catchment and command area.
16	Rain water harvesting.
17	Role of NGOs in watershed
18	Land use capability classification
19-20	Alternate land use systems; agro-forestry; ley farming; *jhum* management - basic concepts, socio-economic aspects, its layout.
21	Drainage, methods of drainage
22	Drainage considerations and agronomic management
23	Rehabilitation of abandoned *jhum*l ands and measures to prevent soil erosion
24	Factors considered in selection of drainage system
25	Reclamation of ill drained soils

Practical

Exercise No.	Title of the exercise
1	Study of different types of erosion
2	Determination of dispersion ratio
3	Estimation of soil loss by Universal Soil Loss Equation
4-5	Measurement of runoff and soil loss
6	Field studies of different soil conservation measures
7-8	Laying out run-off plot and deciding treatments
9	Identification of different grasses and trees for soil conservation
10	Visit to watershed areas
11-12	Visit to a soil conservation research center, demonstration and training centre
13	Visit to Model watershed

AGRON 607
Credit Hour: 2+1
Course Title: STRESS CROP PRODUCTION

Objective: To study various types of stresses in crop production and strategies to overcome them.

Theory

UNIT-I:
Stress and strain terminology; nature and stress injury and resistance; causes of stress, Crop stress detection and Biotic stress

UNIT-II:
Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.

UNIT-III:
High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT-IV:
Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations, Crop water stress index.

UNIT-V:
Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations, Partial root zone drying and its application

UNIT-VI:
Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

UNIT-VII:
Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

UNIT-VIII:

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

1. Determination of electrical conductivity of plant cell sap

2. Determination of osmotic potential and tissue water potential
3. Measurement of transpiration rate
4. Measurement of stomatal conductance
5. Measurement of Relative Water Content of leaf
6. Measurement of electrolytic leakage
7. Growing of plantsins and culture under salt stress for biochemical and physiological studies
8. Studies on effect of osmotic and ionic stress on seed germination and seedling growth
10. Measurement of low temperature injury under field conditions
11. Studies on plant responses to excess water.
12. Determination of leaf water potential
13. Measurement of canopy temperature difference.
14. Studies on water stress indices.
15. Studies on plant responses to deficit water.

Teaching methods/ activities:

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome:

Experience on the knowledge of various types of stresses in crop production and strategies to overcome these.

Suggested Reading:

Baker FWG.1989. Drought Resistance in Cereals. Oxon, UK.

Gupta U.S. (Ed.). 1988. Physiological Aspects of Dryland Farming. Oxford & IBH. Kramer PJ.1983. Water Relations of Plants. Academic Press.

Levitt J.1980.Response of Plants to Environmental Stresses. Vols.I ,II. Academic Press.

Mavi H S.1978. Introduction to Agro-meteorology. Oxford& IBH.

Michael AM & OjhaT P.1981. Principles of Agricultural Engineering. Vol II. Jain Bros.

Nilsen ET & Orcut D M.1996. Physiology of Plants under Stress–Abiotic Factors. John Wiley & Sons.

Singh K. 2000. Plant Productivity under Environmental Stress. Agribios.

Singh K N & Singh R P. 1990. Agronomic Research Towards Sustainable Agriculture. Indian Society of Agronomy, New Delhi.

Somani LL & Totawat K L.1992. Management of Salt-affected Soils and Waters. Agrotech Publ.

Virmani SM, Katyal JC, Eswaran H & Abrol I P.1994. Stressed Ecosystem and Sustainable Agriculture. Oxford & IBH.

Lecture Schedule

Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Stress and strain terminology; nature and stress injury and resistance; causes of stress, Crop stress detection and Biotic stress	03
2.	Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance	02
3.	Chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.	03
4.	High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants,	02
5.	Practical ways to overcome the effect of heat stress through soil and crop manipulations	02
6.	Water deficit stress: meaning of plant water deficient stress and its effect on growth and development	03
7.	Water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop manipulations, Crop water stress index.	04
8.	Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants	02
9.	Excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations,	02
10.	Partial root zone drying and its application	01
11.	Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants	02
12.	Practical ways to overcome the effect of salt stress through soil and crop manipulations.	01

13	Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.	02
14	Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce	02
15	Ways and means to prevent environmental pollution.	01
	Total	**32**

Practical

Sr. No.	Topic	No. of Practical(s)
1.	Determination of electrical conductivity of plant cellsap	01
2.	Determination of osmotic potential and tissue water potential	02
3.	Measurement of transpiration rate	01
4.	Measurement of stomatal conductance	01
5.	Measurement of Relative Water Content of leaf	01
6.	Measurement of electrolytic leakage	01
7.	Growing of plantsins oil and culture under salts tress for biochemical and physiological studies	02
8.	Studies on effect of osmotic and ionic stress on seed germination and seedling growth	01
9.	Measurement of low temperature injury under field conditions	01
10.	Studies on plant responses to excess water.	01
11.	Determination of leaf water potential	01
12.	Measurement of canopy temperature difference.	01
13	Studies on water stress indices.	01
14	Studies on plant responses to deficit water.	01
	Total	**16**

AGRON 608

Credit hour: (2+0)

Title: RESEARCH & PUBLICATION ETHICS

Theory:

Unit I:

Introduction to philosophy: definition, nature and scope, concept, branches

Unit II:

Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit III:

Scientific conduct: Ethics with respectto science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

Unit IV:

Publication ethics: Definition, introduction and importance. Best practices / standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice-versa, type, violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit V:

Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestions tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

Unit VI:

Publication misconduct: Group discussions-subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud fromIndia and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit VII:

Database and Research metrics: Indexing data base, citation database, web of science, scopus etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10 index altmetrics

Teaching methods/activities:
Classroom teaching with AV aids, group discussion, field practical and laboratory visit.
Learning outcome:
Developed skill for research management, quality publication

Lecture Schedule
Theory

Sr. No.	Topic	No. of Lecture (s)
1.	Introduction to philosophy: definition, nature and scope, concept, branches	02
2.	Ethics: definition, moral philosophy, nature of moral judgements and reactions	02
3.	Scientific conduct: Ethics with respect to science and research,	02
4.	Intellectual honesty and research integrity, Scientific misconducts-falsifications, fabrications and plagiarism (FFP):	03
5.	Redundant publications: duplicate and overlapping publications, salamislicing; selective reporting and misrepresentation of data	02
6.	Publication ethics: Definition, introduction and importance. Best practices / standard setting initiatives and guidelines: COPE, WAME etc.	03
7.	Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics	03
8.	Authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals	02
9.	Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies	02
10.	Software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestions tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggester etc.	03
11.	Publication misconduct: Group discussions-subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad.	02
12.	Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools	02
13	Database and Research metrics: Indexing data base, citation database, web of science, scopus etc.	02
14	Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i10 index altmetrics	02
	Total	**32**

A list of international and national reputed Journals

Sr. No	Name of international and national reputed journals	NAAS Score
1	Advances in Agronomy	11.02
2	Agricultural Water Management	8.45
3	Agriculture, Ecosystems & Environment (Netherlands)	9.20
4	Agroforestry Systems	7.24
5	Agronomy Journal (Journal of American Society of Agronomy)	7.54
6	Agronomy for Sustainable Development (Agronomie)	8.84
7	Applied Ecology and Environmental Research	6.46
8	Crop Science	7.48
9	Crop and Pasture Science (Australian Journal of Agricultural Research)	7.28
10	European Journal of Agronomy	8.92
11	Field Crops Research	8.61
12	Indian Journal of Agricultural Sciences	6.00
13	Indian Journal of Agronomy	5.00
14	International Journal of Agricultural Sustainability	7.75
15	International Journal of Water Resources Development	6.90
16	Irrigation Science	8.84
17	Journal of Agricultural Science, Cambridge	8.89
18	Journal of Agronomy and Crop Science	8.62
19	Journal of Crop and Weed	3.59
20	Journal of Farming Systems Research & Development	3.41
21	Journal of Soil and Water Conservation	7.81
22	Journal of Soils and Crops	3.77
23	Journal of Water Resources, Planning and Management	7.76
24	Resources, Conservation and Recycling	8.69
25	Research on Crops	6.00
26	Weed Research	8.02
27	Weed Science	7.68
28	Indian Journal of Weed Science	3.94

Restructured and Revised Syllabus

M.Sc. & Ph. D. (Agriculture)

in

Soil Science

Submitted by

Broad Subject Coordinator
Associate Dean and Principal
College of Agriculture, VNMKV, Parbhani

Discipline Coordinator
Prof. and Head
Dept. of Soil Science & Agricultural Chemistry,
VNMKV, Parbhani

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Discipline: Soil Science

Preamble

Soils comprise a multiple phase system consisting of numerous solid phases (about 50%), a liquid phase (about 25%) and a gas phase (about 25 %). The solids include rock consisting of many different primary and secondary minerals. Super imposed on this inorganic matrix is what Truog (1951) described as the ‘living phase’ which includes bacteria, fungi, actinomycetes, algae, protozoa, nematodes and other forms of life. These living organisms are continuously breaking down organic residues and synthesizing many of the products into body tissues while others are released to the surroundings Many physical, chemical and biological changes continually take place in soils. Physical processes such as wetting, drying, freezing, thawing changing temperatures and leaching modify the surface areas of soil particles. Primary minerals change to secondary minerals as ionic species in solution seek lower free energy levels. In addition, plants capture energy from sun and store in the form of organic compounds. Because of dynamic nature of soils, various changes take place regularly in soils and therefore, it is very essential to know the behaviour of soil solution, matrix potential so that proper technology can be achieved through research works.

Our knowledge has increased rapidly during the last decade concerning the role of macro and micro nutrients in soils, plants, animal nutrition and in food for man. The skills of several scientific disciplines, combined with sophisticated instruments, have extended our knowledge about nutrients in plants and soils to molecular level and to micro environments of roots in soil. One of the cherished objectives of the salient feature of the revised syllabi is to foster high standard in education system of soil science. A paradigm shift is necessary in education prioritization to meet the challenges of the present and future in soil science.

Students, therefore have to be acquainted with the modern concepts of different processes, concepts and development so as to develop competencies on the area of specialization of the subject. For the purpose, it is proposed to revise the course syllabus of Soil Science in the light of the present days need incorporating the basic concepts, developments of the discipline.

The existing M.Sc. (Ag) courses of soil science have been modified taking into account of present day need by incorporating the necessary and important topics in the respective courses such as basic principle of physics applied to soils, fertility status of major soil groups of India, Long term effect of manures and fertilizers on soil fertility and crop productivity, Soil health quality in relation to human health, Speciality fertilizers, Concept of quantity/intensity relationship, Soil mapping, Interaction of clay with humus, pesticides and heavy metals, Soil enzyme, Humus formation, Root rhizosphere and Biodegradation of pesticide. The new topics are covered in Ph.D. courses as Soil-plant-atmospheric continuum (SPAC), Kinetics studies of nutrients in soils, Climate change on soil properties and Carbon sequestration. Major changes have been made in some of the existing courses like soil fertility and fertilizer uses, soil biology and biochemistry and Analytical technique and instrumental methods in soil and plant analysis under M.Sc. programme and Biochemistry of soil organic matter under Ph.D. programme. As a part of course curriculum, M.Sc. (Ag) soil science was restructured to equip students to tackle emerging issues by inclusion of two new courses on (i) Soil survey and land use planning (ii) Introduction to a notechnology. The Ph.D. courses of soil science was revised by adding four important new courses (i) Recent trend in soil microbial diversity (ii) Soil resource management (iii) Modelling of soil plant system (iv) Clay mineralogy.

Committee for Soil Science

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub-Committees	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Physical Science	**Soil Science**	M.Sc. (Agri.)	Ph.D.	**Dr. Syed Ismail**, ADP, CoA, VNMKV, Parbhani	**Dr. P.H.Vaidya** Prof. and Head Dept. Soil Science & Agricultural Chemistry, VNMKC, Parbhani

Sub-Committee constituted for the finalization of common syllabi in Soil Science Discipline

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	Name	
1	Dr. Syed Ismail ADP, CoA, VNMKV, Parbhani Email:syedismail.ibrahim@gmail.com Mobile:7588082045	Broad Subject Coordinator
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6	Dr. A. G. Durgude Associate Professor, Soil Science and Agricultural Chemistry, MPKV, Rahuri E-mail:durgudeag@rediffmail.com Mobile:9822598964	Member
7	Dr. N. M. Konde, Assistant Professor, Soil Science and Agricultural Chemistry, Dr. PDKV, Akola	Member

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9	Dr. S.P. Zade, Assistant Professor, Soil Science and Agricultural Chemistry, Parbhani E-mail: spzade@yahoo.co.in Mobile: 9049641332	Member
Invited Member During Final Meeting		
1	Dr. R. S. Thakare, Associate Professor, Dept. of SSAC, MPKV, Rahuri	Member
2	Dr. A.L. Dhamak , Associate Professor, Dept. of SSAC, VNMKV, Parbhani Mobile:	Member
3	Dr. S.L. Waikar , Assistant Professor, Dept. of SSAC, Parbhani	Member
4	Dr. R.V. Dhopavkar , Assistant Professor Dept. of SSAC, Dr. BSKKV, Dapoli	Member

Implementation of New Curriculum

The universities offering PG programmes in Soil Science need to be supported for establishing specialized laboratories equipped with state-of-the art equipment's for conducting practical classes especially, Soil Genesis, Soil Classification, Soil Survey, Soil fertility, Soil Water and Plant analysis, Soil management, Water management, Conservation Agriculture, Remote sensing, Precision Agriculture, Nano technology & Organic farming.

One-time catch-up grant should be awarded to each SAU, offering PG programmes in Soil Science for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculties in each department under SAU should be given on job training in reputed national and international institutes. To execute the new PG and Ph.D. programmes in Soil Science discipline in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

The already existing M.Sc. and Ph.D. Programmes in Soil Science will be considered at par with the recommended M.Sc. & Ph.D. programme by V^{th} Deans Committee for admission and employment.

Expected Outcome

- Revamping of post graduate programme in whole of soil science throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of farmers governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents &Credit Requirements

Minimum Residential Requirement:
M.Sc.: 4 Semesters
Ph.D.: 6 Semesters

Name of the Departments / Divisions

- Soil Science

Nomenclature of Degree Programme

(a) M.Sc. Programmes

i) M.Sc. (Agriculture) Soil Science

(b) Ph.D. Programmes

i) Ph.D. (Agriculture) Soil Science

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also been given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

Master's Degree Programme

B.Sc.(Agri.) / **B. Sc. (Hons.) Agriculture,** B. Sc. (Hort.) / B.Sc. (Hons.) Horticulture / B. Sc. (Forestry) / B.Sc. (Hons.) under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Agriculture conducted by competent authority.

Doctoral Degree Programme

Master's degree in concerned discipline with minimum of 6.50/10 or equivalent percentage of marks and based on CET score CET conducted by MAUEB or AIEEA – ICAR, Agricultural Universities (AUs) which have expressed their willingness to utilize NTA scores for their PG admissions. If required the scores will be provided by NTA.

(i) Master Degree in the concerned Department/Discipline of Soil Science and Agricultural Chemistry / Soil Science/ Agricultural Chemistry/Land Resource Management and having appearing the Common Entrance Test of Soil Science subject conducted by competent authority.

Sr. No	**Name of Department**	**Specialization in Ph. D. Soil Science**	**Eligibility criteria**
1.	Soil Science	Ph. D (Agriculture) Soil Science	M.Sc. (Agriculture) Soil Science and Agricultural Chemistry / Soil Science/ Agricultural Chemistry/Land Resource Management and have appearing common Entrance Test in Soil Science (Relevant to Degree Program)

Credit Requirements

Course Details	**Master's Degree**	**Doctoral Degree**
Major Courses	20	15
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

M.Sc. (Agri) Soil Science Course Structure

1. M.Sc. (Agriculture) Soil Science

Course Code	Course Title	Credit Hours
*SOIL 501	Soil physics	(2+1)
*SOIL 502	Soil fertility and fertilizer use	(2+1)
*SOIL 503	Soil chemistry	(2+1)
*SOIL 504	Soil mineralogy, genesis and classification	(2+1)
SOIL 505	Soil erosion and conservation	(2+1)
SOIL 506	Soil Biology and Biochemistry	(2+1)
SOIL 507	Radioisotopes in soil and plant studies	(1+1)
SOIL 508	Soil, water and air pollution	(2+1)
SOIL 509	Remote sensing and GIS technique for soil and crop studies	(2+1)
SOIL 510	Analytical technique and instrumental methods in soil and Plant analysis	(0+2)
SOIL 511	Management of problematic soils and water	(1+1)
SOIL 512	Land degradation and restoration	(1+0)
SOIL 513	Soil Survey and Landuse Planning	(2+0)
SOIL 514	Introduction to nano technology	(2+1)
SOIL 591	Master's Seminar	(1+0)
SOIL 599	Master's Research	-30

***Compulsory Courses**

Semester wise Courses offered based on credit requirement

Course Code	**Semester**	**Course Title**	**Credit Hrs.**
*SOIL 501	I	Soil physics	(2+1)
*SOIL 502	II	Soil fertility and fertilizer use	(2+1)
*SOIL 503	I	Soil chemistry	(2+1)
*SOIL 504	I	Soil mineralogy, genesis and classification	(2+1)
SOIL 505	II	Soil erosion and conservation	(2+1)
SOIL 506	II	Soil Biology and Biochemistry	(2+1)
SOIL 507	II	Radio isotopes in soil and plant studies	(1+1)
SOIL 508	II	Soil, water and air pollution	(2+1)
SOIL 509	II	Remote sensing and GIS technique for soil and crop studies	(2+1)
SOIL 510	II	Analytical technique and instrumental methods in soil and Plant analysis	(0+2)
SOIL 511	III	Management of problematic soils and water	(1+1)
SOIL 512	III	Land degradation and restoration	(1+0)

SOIL 513	III	Soil Survey and Landuse Planning	(2+0)
SOIL 514	III	Introduction to nano technology	(2+1)
SOIL 591	III	Master's Seminar	(1+0)
			24 +13 = 37
SOIL 599	III &IV	Master's Research	0+30
		Total	**24+43=67**

***Compulsory Courses**

Common Non Credit Compulsory PGS Courses:

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1=1
PGS 504	I	Basic Concepts in Laboratory Techniques	0+1=1
PGS 502	I	Technical Writing and Communications Skills	0+1=1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0=1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0=1

Supporting/Optional Courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agricultural Metrology
3. Soil Science
4. Biochemistry
5. Horticulture
6. Forestry
7. Organic Farming
8. Computer Science and Information Technology

Some of the suggested courses are

Course Code	Semester	Course Title	Credit Hrs.
BIOCHEM501	I	Basic Biochemistry	**3+1=4**
STAT 502,	I	Statistical Methods for Applied Sciences	**3+1=4**
STAT 511	II	Experimental Designs	**2+1=3**
COM 501	II	Information Technology in Agriculture	**2+1=3**
Any other course	Any relevant subject to student research topic		

Minor Disciplines:

1. Agronomy
2. Plant Physiology
3. Plant Protection
4. Microbiology
5. Agriculture Engineering
6. Natural Resource Management

Suggestive Minor Courses:

Course Code	Semester	Course Title	Credit Hrs.
AGRON 505	I	Conservation Agriculture	1+1=2
AGRON 512	I	Dry land farming and watershed management	2+1=3
PP 501	I	Principles of Plant Physiology Plant Water Relationship and Mineral nutrition	2+1=3
AGRON 513	II	Principal and practices of organic farming	2+1=3
Any other course	Relevant to student research topic		

Compulsory Non Credit Deficiency Courses (those who are non Agricultural Graduates)

Students from Non Agriculture stream will be required to completed Non credit deficiency courses (6-10 credits) from the courses related to the discipline in which admitted and as decided by the Student Advisory committee.

Sr. No.	Semester	Course No.	Credits	Course Title
1	I	SSAC 111	3(2+1)	Fundamentals of Soil Science
2	II	SSAC 242	2(1+1)	Problematic Soils and their Management
3	I	SSAC 353	3(2+1)	Manures, Fertilizers and Soil Fertility Management
4	II	ELE SSAC 364	3(2+1)	Agrochemicals

Ph.D. (Agriculture) Soil Science

Course Structure

Course Code	Course Title	Credit Hours
SOIL 601	Recent trends in soil physics	2+0
SOIL 602	Modern concept in soil fertility	2+0
SOIL 603*	Physical chemistry of soil	2+0
SOIL 604*	Soil genesis and micro morphology	2+0
SOIL 605	Bio-chemistry of soil organic matter	2+0
SOIL 606	Soil resource management	3+0
SOIL 607	Modelling of soil plant system	2+0
SOIL 608	Clay Mineralogy	2+1
SOIL 609	Recent trends in soil microbial biodiversity	2+1
SOIL 691	Doctoral seminar	1+0
SOIL 692	Doctoral seminar	1+0
SOIL 699	Doctoral Research	-75

*Indicates Core Courses which are Compulsory for Ph.D. Programme

Semester wise core Courses offered based on credit requirement

1. **Ph. D. (Agriculture) Soil Science**

Course Code	Semester	Course Title	Credit Hrs.
SOIL 601	I	Recent trends in soil physics	2+0
SOIL 602	II	Modern concept in soil fertility	2+0
SOIL 603*	I	Physical chemistry of soil	2+0
SOIL 604*	I	Soil genesis and micro morphology	2+0
SOIL 605	II	Bio-chemistry of soil organic matter	2+0
SOIL 606	III	Soil resource management	3+0
SOIL 607	III	Modeling of soil plant system	2+0
SOIL 608	II	Clay Mineralogy	2+1
SOIL 609	II	Recent trends in soil microbial biodiversity	2+1
SOIL 691	III	Doctoral seminar	1+0
SOIL 692	IV	Doctoral seminar	1+0
			21+2
SOIL 699	III-VI	Doctoral research	70
		Total	**21+72**

Supporting/Optional Courses:

Supporting/optional courses of 500/600 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agricultural Metrology
3. Soil Science
4. Biochemistry
5. Horticulture
6. Forestry
7. Computer Science and Information Technology

SupportingCourse Code	Semester	Course Title	Credit Hrs.
PP 606	I	Global Climate Change and Crop Response	(2+0)
FAS 612	II	Abiotic Stress Management in Fruit Crops	(2+1)
VSC 603	II	Abiotic Stress Management in Vegetable Crops	(2+1)
BIOCHEM-603	II	Biochemistry of Biotic and Abiotic Stress	(3+0)
STAT 604	I	Advance Statistical Method	(2+1)
STAT 612	I	Advance Design and Experiments	(2+1)
AGM 601*	II	Climate Change and Sustainable Development	(2+1)
Any other course	Relevant to student research topic		

Minor Disciplines:

1. Agronomy
2. Plant Physiology
3. Plant Protection
4. Microbiology
5. Agriculture Engineering
6. Natural Resource Management

Minor Course Code	Semester	Course Title	Credit Hrs.
AGRON 602	I	Recent trends in crop growth and productivity	(2+1)
AGRON 603	I	Irrigation Management	(2+1)
AGRON 606	II	Soil Conservation and Watershed Management	(2+1)
AGRON 607	II	Stress Crop Production	(2+1)
FAS 612	II	Abiotic Stress Management in Fruit Crops	(2+1)
VSC 603	II	Abiotic Stress Management in Vegetable Crops	(2+1)
PP 606	I	Global Climate Change and Crop Response	(2+0)
Any other course	Relevant to student research topic		

Department of Soil Science Course Plan Major 20 + Minor 08+ Supporting 06 + NCCC 05 + Seminar 01+ Research 30 = 70/73			
Course No	Title of Course	Credit	Remark
Semester I			
SOIL 501*	Soil physics*	(2+1)	Major
SOIL 503*	Soil chemistry*	(2+1)	Major
SOIL 504*	Soil mineralogy, genesis and classification*	(2+1)	Major
AGRON 505	Conservation Agriculture	(1+1)	Minor
PP 501	Principles of Plant Physiology Plant Water Relationship and Mineral nutrition	(2+1)	Minor
BIOCHEM 501	Basic Biochemistry	(3+1)	Supporting
	or		
AGRO/HORT/BOT/ BIOCHEM/STAT	Relevant to student Research	(3)	Supporting
PGS 501	Library and Information Services	(0+1)	NCCC
PGS 504	Basic Concept in Laboratory Techniques	(0+1)	NCCC
	Total	20	
Semester II			
SOIL 502*	Soil fertility and fertilizer use	(2+1)	Major
SOIL 510	Analytical technique and instrumental methods in soil and Plant analysis	(0+2)	Major
SOIL 506	Soil Biology and Biochemistry	(2+1)	Major
SOIL 509	Remote sensing and GIS technique for soil and crop studies	(2+1)	Major
OR			
SOIL508	Soil, water and air pollution	(2+1)	Major
OR			
SOIL 505	Soil Erosion and Conservation	(2+1)	Major
AGRO 513	Principles and practices of organic farming	(2+1)	Minor
STAT 511	Experimental Designs	(2+1)	Supporting
PGS 502	Technical writing and Communication Skill	(0+1)	NCCC
PGS 503	Intellectual property and management in agriculture	(1+0)	NCCC
	Total	19	
Semester III			
SOIL511	Management of problematic soils and water	(1+1)	Major
SOIL591	Master's Seminar	(1+0)	Major
PGS 505	Agricultural Research Ethics and Rural Development Programme	(1+0)	NCCC
SOIL 599	Masters Research	(0+10)	Research
	Total	14	
Semester IV			
SOIL 599	Masters Research	(0+20)	Research
Major 22 + Minor 8 + Supporting 7 + NCCC5 Seminar 1 + Research 30 = Total 73		73	

Course contents
M.Sc. (Agri.) in Soil Science

Course Title : Soil Physics
Course Code : SOIL 501
Credit Hours :2+1

Aim of the course

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

Theory

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

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

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage- basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and erodability

Unit IV

Soil structure- genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil- water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil- moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant- atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Unit I X

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

Determination of B.D,P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method, Measurement of Atterberg limits, Aggregate analysis-dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Reading

1. Baver LD,Gardner WH and Gardner WR.1972. Soil Physics. John Wiley & Sons.
2. Ghildyal BP and Tripathi RP.2001. Soil Physics. New Age International.
3. Hanks JR and Ashcroft GL.1980. Applied Soil Physics. Springer Verlag.
4. Hillel D.1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
5. Hillel D.1980. Applications of Soil Physics. Academic Press.
6. Hillel D.1980. Fundamentals of Soil Physics. Academic Press.
7. Hillel D.1998. Environmental Soil Physics. Academic Press.
8. Hillel D.2003. Introduction to Environmental Soil Physics. Academic Press.
9. Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
10. Kirkham D and Powers WL.1972. Advanced Soil Physics. Wiley-Interscience.
11. Kohnke H.1968. *Soil Physics*. McGraw Hill.
12. Lal R and Shukla MK.2004. *Principles of Soil Physics*. Marcel Dekker.
13. OswalMC.1994.*SoilPhysics*.Oxford&IBH.
14. 14 Text books of soil physics by Arun Kumar Saha, Anuradha Saha Kalyani Publication New Delhi
15. 15Soil Physics An Introduction By Manoj K. Shukla Published December 2, 2013 by CRC Press 478 Pages 201 B/W Illustrations
16. 16 Principles of Soil Physics By Rattan Lal, Manoj K. Shukla Published September 27, 2019 by CRC Press 736 Pages
17. 17Applications of Soil Physics 1st Edition - October 28, 1980 Daniel Hillel Elsevier
18. 18 Fundamental Principal of Soil Science by Deepak Sarkar and Abhijit Haldar Today and tomorrows Printers and Publishers

Teaching Schedule
Theory

Unit	Lecture No.	Topics to be covered	Weightage(%)
I	1	Basic Principal of physics applied to soil	3
	2	Soil as three phase system.	4
II	3, 4	Soil texture, textural class, mechanical analysis , Stoke's law, specific surface	7
III	5, 6, 7	Soil consistence, dispersion and workability of soil, soil compaction and consolidation, soil strength, swelling and shrinkage basic concept ,Alleviation of soil physical constraints for crop production. Soil erosion and edibility	4
IV	8, 9	Soil structure, genesis, types, characterization and management of soil structure, soil aggregation, aggregate stability, characteristics of good soil tilth	6
	10, 11	Soil crusting, mechanism, factor affecting and evaluation, soil conditioner, puddling its effect on soil physical properties, clod formation	7
V	12, 13	Soil water content and potential, soil water retention, soil water constant	7
	14, 15, 16	Measurement of soil water content, energy state of soil water, soil water potential	7
	17, 18	Soil moisture characteristics curve, hysteresis measurement of soil water potential	5
		Mid Term	
VI	19	Water flow in saturated and unsaturated soil	4
	20	Poiseuille's law, Darcy's law, hydraulic conductivity	4
	21	Permeability and fluidity, hydraulic diffusivity	4
	22	Measurement of hydraulic conductivity in saturated and unsaturated soil	4
VII	23	Infiltration, internal drainage and redistribution	4
	24	Soil water losses, Hydrologic cycle, field water balance soil plant atmosphere continuum	5
VIII	25, 26	Composition of soil air, renewal of soil air convective flow and diffusion	5
	27, 28	Measurement of soil aeration, aeration requirement for plant growth, soil air management	5
IX	29, 30	Mode of energy transfer in soil ,energy balance , thermal properties of soil, measurement of soil temperature modification of temperature	5
	31, 32, 33	Soil temperature in relation to plant growth,	5
	34, 35, 36	Soil temperature management	5

Practical Teaching Schedule

Sr. No.	Exercise No.	Name of Exercise
1	1-2	Determination of BD by core and clod method,

2	3-4	Determination PD by pychnometer method and Mass volume relationship of soil.
3	5-6	Mechanical analysis by international pipette and hydrometer method and Determination of textural class by USDA Traingal
4	7	Determination of soil consistence by Atterberg limits
5	8	Water stable aggregate analysis by dry and wet sieving method (Yoder's apparatus)
6	9	Determination of soil moisture content by Direct method-gravimetric
9	10-11	Determination of soil moisture content by indirect method. Tenciometer and Gypsum block .
10	12	Determination of soil moisture characteristics curve by pressure plate apparatus for coarse and fine textured soil
11	13	Determination of macro and micro pore size distribution
12	14	Determination of hydraulic conductivity under saturated and unsaturated condition
13	15	Determination of infiltration rate by double ring infiltrometer
14	16	Determination of oxygen diffusion rate by platinum electrode method
15	17	Determination of soil temperature by soil thermometer
16	18	Estimation of water balance component in bare and cropped field

Course Title :**Soil Fertility and Fertilizer Use**

Course Code : **SOIL 502**

Credit Hours :**2 +1**

Aim of the course

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

I. Theory

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India; Special emphasis on Maharashtra nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soilandfertilizernitrogen–sources,forms,immobilizationandmineralization,nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit III

Soil and fertilizer phosphorus – sources, forms, immobilization, mineralization, fixation, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.

Unit IV

Potassium – Sources, forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit V

Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Unit VI

Micronutrients – Source, factors affecting their availability, critical limits in soils and plants, correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit VII

Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

Unit VIII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India,

Unit IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, DRIS, critical limits of nutrients

Unit X

Definition and concepts of soil health and soil quality; Longterm effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students. Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Reading

- Brady NC and Weil RR.2002. *The Nature and Properties of Soils*. 13^{th} Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H.1992. *Trace Elements in Soils and Plants* .CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K.2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh JG.2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM.1991. *Micronutrients in Agriculture*. 2ndEd. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF.2002. *Soils and Environmental Quality*.2^{nd} Ed. CRC Press.
- Stevenson FJ and Cole MA.1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL.1999. *Soil Fertility and Fertilizers*. 5thEd. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005.*Soils and Soil Fertility*. Blackwell.
- Soil Fertility Fertilizers and Agrochemicals Joga Pravin K. 2018 Astral International pub Ltd.
- Fertilizers in Indian Agriculture-from 20^{th} to 21^{st} century 2004 Dr. HLS Tondon ,FDCO Sohna Road Gurgaon122018
- Soil Fertility, Fertilizers and INM 2011 Dr. HLS Tondon FDCO Sohna Road Gurgaon122018

Teaching Schedule
Theory

Unit	Lecture No.	Topics to be covered	Weightage (%)
I	1	Soil fertility and soil productivity; fertility status of major soils group of India; Special emphasis on Maharashtra	3
	2	Nutrient sources- fertilizers and manures	3
	3	Criteria of essentiality, classification, law of minimum and maximum,	5
	4	Functions and deficiency symptoms of primary, secondary and micronutrients nutrients	5
	5	Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity	5
II	6-7	Sources and forms of nitrogen in soils – immobilization and mineralization (nitrification, denitrification,)	3
	8	Biological N fixation Factors affecting N fixation,	3
	9-10	Nitrogen fertilizers, their classification and fertilizer N management in Low land upland conditions, fertilizer N use efficiency	3
III	11-12	Soil fertilizer Phosphorus –, forms and Sources of soil P , immobilization and mineralization of soil P	3
	13	Factors affecting the P availability in soil	2
	14	Phosphatic fertilizers, their classification and behaviour and management of P fertilizers under field conditions.	4
IV	15	Forms and sources of potassium in soil, factors affecting Potassium availability (soil and plant factors)	4
	16	Mechanism of potassium fixation factors affecting it	4
	17	K fertilizers and their classification and management of K fertilizers under field conditions	4
	18	**Mid Term**	
V	19	Sulphur- forms , and sources of sulphur in soils, S behaviour in soils	2
	20	Sulphur fertilizers and their behaviour in soils, role in crop and human health	2
	21	Calcium and magnesium- forms and sources of Ca & Mg in soils, Ca & Mg availability in soils	2
	22	Management of sulphur, calcium and magnesium fertilizers.	3
VI	23-24	Micronutrients – Sources, critical limits in soil and plants, micronutrient availability in soil and factors affecting it.	5
	25	Deficiency symptoms and their corrections in plants.	3
	26	Role of chelates in nutrient availability	3
VII	27	Common soil test methods for fertilizer recommendations	4
	28	Quantity /intensity of phosphorus and potassium,	4
	29	Soil test crop response correlations and response functions	3
VIII	30	Fertilizer use efficiency –site specific nutrient management and plant need based nutrient management	3
	31	Integrated nutrient management – specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India	3
IX	32	Soil fertility evaluation – classification DRIS, Methods of	3

		determination of critical limit biological methods	
	33	Soil and plant tissue test	3
	34	Soil quality to sustainable agriculture-	3
X	35-36	Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.	3
		Total	**100**

Practical's

Sr. No.	Exercise No.	Name of Exercise
1	1	Soil and plant sampling and processing technique for chemical analysis.
2	2	Determination of total and organic carbon in soil.
3	3	Principles of colorimetric, flame photometry and atomic absorption spectrophotometry
4	4	Determination of available nitrogen
5	5	Determination of ammonical and nitrate nitrogen
6	6	Determination of available phosphorus
7	7	Determination of available potassium
8	8	Determination of exchangeable cations Ca, Mg, Na and K
9	9	Determination of available S
10	10	Determination of DTPA- Fe , Mn, Zn and Cu from soil
11	11	Determination of available B
12	12	Determination of available Mo
13	13	Preparation of an acid extract
14	14	Determination of total nitrogen in plants
15	15	Determination of total P in plants
16	16	Determination of total K in plants
17	17	Determination of total S in plants
18	18	Determination of total micronutrients in plants

Course Title :Soil Chemistry
Course Code :SOIL 503
Credit Hours :2+1

Aim of the course

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory

Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II

Elements of equilibrium thermo dynamics, chemical equilibria, electro chemistry and chemical kinetics.

Unit III

Soil colloids: inorganic and organic colloids- origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/ flocculation and peptization of soil colloids; electro metric properties of soil colloids sorption properties of soil colloids; soil organic matter-fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV

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

Unit V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation- dissolution equilibria; Concept of quantity/ intensity (Q/I) relationship; step and constant-rate K; management aspects.

Unit VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII

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

Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

Practical

Preparation of saturation paste extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophoto metric studies and the D(E4/E6) values at two pH values, Adsorption-desorption of phosphate/ sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/ fluoride / sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of chemical behavior of soil and their utility in research for solving field problem.

Suggested Reading

- Kim H. Tan , 2010. Principles of Soil Chemistry,4th Edition, Kindle Edition.
- Daniel G. Strawn, Hinrich L. Bohn, George A. O' Connor 2019 *Soil Chemistry, 5th Edition*
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi

- Indian Society of Soil Science 2015.Soil Science: An Introduction. ISSS, New Delhi
- Bear RE.1964.*Chemistry of the Soil* .Oxford and IBH.
- Sanyal Text Book Of Soil Chemistry Jain Books & Periodicals 1586/113,Ganesh Pura, Tri Nagar, Delhi – 110035
- Bolt GH and Bruggenwert MGM.1978. *Soil Chemistry*. Elsevier.
- Greenland DJ and Hayes MHB. 1981.*Chemistry of Soil Processes*. John Wiley &Sons.
- Greenland DJ and Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB.1994. *Environmental Chemistry of Soils* .Oxford University Press.
- Sposito G.1981.*TheThermodynamics of Soil Solutions*. Oxford University Press.
- Sposito G.1984. *The Surface Chemistry of Soils* .Oxford University Press.
- Sposito G.1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ.1994. *Humus Chemistry*. 2ndEd. John Wiley & Sons.
- VanOlphan H.1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

Teaching Schedule

Theory

Unit	Lecture No.	Topics to be covered	Weightage In %
I	1, 2	Chemical (elemental) composition of the earth's crust and soils, Rocks and minerals in earth's crust	4
II	3, 4, 5	Elements of equilibrium thermo dynamics, Chemical equilibria, Chemical and SI units, Ion activity, Activity coefficient, Complex ion and ion pairs, Ionic strength, Hydrolysis and deprotonation, Acids and bases,	7
	6, 7, 8	Solubility product, Soil reaction coefficient, Low of mass action, Soil solution, Electrochemistry and chemical kinetics, Reaction order and rate constant, Factors affecting rates of reactions, Microbes catalysis	7
III	9, 10, 11	Soil colloids: inorganic and organic colloids, Classification structure transformation and properties of inorganic colloids, Origin of charge, Concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, Surface charge characteristics of soils	10
	12, 13	Diffuse double layer theories of soil colloids, Zeta potential, stability, coagulation/flocculation and peptization of soil colloids	7
	14, 15, 16, 17	Electrometric properties of soil colloids; Sorption properties of soil colloids; Soil organic matter - fractionation of soil organic matter and different fractions, Characterization of organic matter, Humus formation, Clay-organic interactions	10
		Mid Term	
IV	18, 19	Ion exchange processes in soil; Cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), Schofield's Ratio Law	8

	20, 21, 22	Adsorption isotherms, Equations used to described the adsorption isotherm, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics	10
	23, 24, 25	Anion and ligand exchange–innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; Experimental methods to study ion exchange phenomena and practical implications in plant nutrition	8
V	26, 27, 28, 29	Potassium, phosphate and ammonium fixation in soils covering specific and non- specific sorption; Precipitation-dissolution equilibria; Concept of quantity/intensity(Q/ I) relationship; Step and constant-rate K; Management aspects	8
VI	30, 31	Chemistry of acid soils; Active and potential acidity; Lime potential; Sub-soil acidity, Nutrient transformation in acid soils, Eh-pH diagram	7
VII	32, 33, 34	Chemistry of salt-affected soils and amendments; Soil pH, ECe, ESP, SAR and important relations; Soil management and amendments	7
VII I	35, 36	Chemistry and electrochemistry of submerged soils, Chemical changes occurring in submerged soil, Geochemistry of micronutrients, Environmental soil chemistry	7

Practical

Exercise No.	**Content**
1, 2	Preparation of saturation paste extract and measurement of pHe, ECe, CO_3, HCO_3, Ca^{2+}, Mg^{2+}, K^+ and Na^+
3, 4	Determination of CEC and AEC of soils.
5	Analysis of equilibrium soil solution for pH, EC, E_h by use of E_h-pH meter and conductivity meter.
6	Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometer titration method.
7, 8	Extraction of soil humic substances
9	Potentiometer and condutometeric titration of soil humic and fulvic acids.
10	Determination of E_4/E_6 ratio of soil humic and fulvic acids by visible spectrophoto metric studies and the E_4/E_6values at two pH values.
11, 12	Determination of Adsorption- desorption of phosphate/sulphate by soil using simple adsorption isotherm.
13, 14	Construction of adsorption envelope of soils by using phosphate/fluoride / sulphate and ascertaining the mechanism of the ligand exchange process involved.
15	Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method.
16	Determination of Q/I relationship of potassium
17	Determination of lime requirement of an acid soil by buffer method.
18	Determination of gypsum requirement of an alkali soil.

Course Title :Soil Mineralogy, Genesis and Classification
Course Code :SOIL 504
Credit Hours :2+1

Aim of the course

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis interms of factors and processes of soil formation, andtoenablestudentsconductsoilsurveyandinterpretsoilsurveyreportsintermsoflandusep lanning.

Theory

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps–usefulness. Soil survey, type of soil survey conventional and modern, data interpretations; soil mapping, thematic soil maps by using RS & GIS, cartography, mapping units, techniques for generation of soil maps. Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application;

Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database interms of soil quality

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil taxonomy and genesis and their utility in research for solving field problem.

Suggested Reading

- Buol EW, Hole ED, MacCracken RJ and Southard RJ.1997. *Soil Genesis and Classification*. 4thEd. Panima Publ.
- Sehgal J.2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J.2002. *Pedology-Concepts and Applications*. Kalyani Publ..
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Indian Society of Soil Science. 2015. *Soil Science and Introduction*. ISSS, New Delhi.
- Rattan, J.C. Katyal, B.S. Dwivedi, A.K. Sarkar and T. Bhattacharrya J.C. Tarafdar and S.S.Kukal ; 2020 *Soil Science and Introduction*, Indian Society of Soil Science
- T .Bhattacharyya 2021, Soil Studies Now and Beyond, Walnut publication New Delhi
- T. Bhattacharyya 2021, Information Systems and Ecosystems Services : Soil as Examples Walnut Publication New Delhi
- Soil Series of Maharashtra 1999, NBSS & LUP ICAR , Nagpur
- Soil Survey Manual 2009 NBSS & LUP ICAR , Nagpur
- Brady NC and Weil RR.2002. *The Nature and Properties of Soils*.13thEd. Pearson Edu.
- Dixon JB and Weed SB.1989. *Minerals in Soil Environments*. 2ndEd. Soil Science Society of America, Madison.
- Grim RE.1968. *Clay Mineralogy*. McGraw Hill.
- USDA.1999. *Soil Taxonomy*. Hand Book No.436.2ndEd. USDANRCS, Washington.
- Wade FA and Mattox RB.1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Wilding LP and Smeck NE.1983. *Pedogenesis and Soil Taxonomy*: II. *The Soil Orders*. Elsevier.
- Wilding NE and Holl GF. (Eds.).1983. *Pedogenesis and Soil Taxonomy*.I.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topic	Weight age (%)
I	1-3	Fundamentals of crystallography, space lattice, coordination theory isomorphism and polymorphism	10
II	4-6	Classification, structure, chemical composition and properties of minerals	10
	7-9	Genesis and transformation of crystalline and non-crystalline clay minerals.	6
	10-12	Identification of clay minerals, amorphous soil constituents and other non-crystalline silicate minerals in Indian soil by using advance methods (XRD, SEM, TEM, IR, DTA etc)	6
	13-15	Role of minerals in plant nutrition interaction of clay with humus	6
		MID TERM	
III	16-17	Factors of soil formation and soil formation model and soil	6

		forming processes	
	18-19	Weathering of rocks and minerals transformations	5
	20	Soil profile and master and Subsurface horizon	5
	21-22	Weathering sequences of minerals with special reference to Indian soil	6
IV	23	Soil individual and its concept,	5
	24-26	soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy	5
	27-29	soil survey, type of soil survey conventional and modern, data interpretations; soil mapping, thematic soil maps by using GIS, cartography, mapping units, techniques for generation of soil maps.	6
	30-32	Landform – soil relationship; major soil groups of India with special reference to respective states	8
	33-34	land capability classification and land irrigability classification;	8
	35-36	land evaluation and land use type (LUT) – concept and application;	8

Practical

Ex. No.	Name of practical Exercise
1-2	Mechanical analysis of soil
3-4	Determination of specific surface area of clay fraction
5-6	Determination of CEC of clay fraction
7-9	Identification and quantification of minerals in soil fractions
10-12	Morphological properties of soil profile in different land forms Viz, Vertisols, Inceptisols and Entisols etc. (Specially emphasis on Maharashtra)
13-14	Classification of soils by using USDA classification (Soil Taxonomy)
15-16	Calculation of weathering indices and its application in soil formation.
17-18	Grouping of soils by using available data base in terms of soil quality

Course Title : Soil Erosion and Conservation
Course Code : SOIL 505
Credit Hours : 2+1

Aim of the course

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Unit I

History, distribution, identification and description of soil erosion problems in India.

Unit II

Forms/type of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

Unit III

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

Unit IV

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

Unit V

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

Unit VI

Watershed management- concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio economic aspects of watershed management; use of remote sensing in assessment and planning of watersheds, sediment measurement; case studies in respect to monitoring and evaluation of watersheds;

Practical

- Determination of different soil erodibility indices-suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/ moisture equivalent ratio, percolation ratio, raindrop perodibility index
- Computation of kinetic energy of falling raindrops
- Computation of rainfall erosivity index (EI30) using raingauge data
- Land capability classification of a watershed
- Visits to a watersheds

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil conservation and their utility in research for solving field problem.

Suggested Reading

- Biswas TD and Narayanasamy G.(Eds.)1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No.17.
- R. P. C. Morgan. 2005 Soil Erosion and Conservation, Third Edition, Blackwell Publishing 350 Main Street, Malden, MA 02148-5020, USA.
- Hudson and Norman, Soil Conservation 3rd Editions 2015, , NIPA Books
- Dr. R. Suresh, Soil and Water Conservation Engineering Standards publishers and Distributers.
- R K Mehra (Author) ICAR Text book of Soil Science HB Hardcover – 1 January 2006
- RPC Morgan. Soil Erosion and Conservation
- Doran JW and Jones AJ.1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ.No.49, Madison, USA.
- Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP.1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.
- Hudson N.1995. *Soil Conservation*. Iowa State University Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Oswal MC.1994. *Soil Physics* .Oxford & IBH.

Teaching Schedule

Unit	No. of Lecture	Topic	Weightage %
I	1&2	History, distribution, identification and description of soil erosion problems in India.	08
II	3&4	Forms/type of soil erosion; Effects of soil erosion and factors affecting soil erosion;	04
	5,6&7	Types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy;	06
	8&9	Factors affecting water erosion; empirical and quantitative estimation of water erosion;	04
	10	Methods of measurement and prediction of runoff;	04
	11&12	Soil losses in relation to soil properties and precipitation.	04
III	13&14	Wind erosion- types of wind erosion	04
	15&16	Mechanism and factors affecting wind erosion;	04
	17	Extent of problem in the country of wind erosion	06
		Mid Term	
IV	18	Principles of erosion control	06
	19&20	Erosion control measures–agronomical and engineering;	08
	21,22&23	Erosion control structures- their design and layout.	06
V	24&25	Soil conservation planning;	06
	26	Land capability classification;	04
	27,28&29	Soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wetlands.	04
VI	30	Watershed management-concept, objectives and approach;	06
	31	Water harvesting and recycling;	04
	32&33	Flood control in watershed management; socio economic aspects	04

		of watershed management;	
	34&35	Use of remote sensing in assessment and planning of watersheds, sediment measurement;	04
	36	Case studies in respect to monitoring and evaluation of watersheds;	04

Practical's

Sr.No	Exercise Number	Name of Practical
1	1-2	Determination of (erodibility indices) soil suspense on percentage.
2	3-4	Determination of soil (erodibility indices) dispersion ratio.
3	5-6	Determination of soil erosion ratio.
4	7-8	Determination of clay ratio from soil.
5	9-10	Determination of clay/moisture equivalent ratio.
6	11-12	Determination of percolation ratio of soil.
7	13-14	Determination of raindrop perodibility index
8	15	Computation of kinetic energy of falling rain drops
9	16	Computation of rainfall erosivity index (EI30) using raingauge data
10	17	Land capability classification of a watershed
11	18	Visits to a watersheds

Course Title : **Soil Biology and Biochemistry**
Course Code : **SOIL 506**
Credit Hours : **2+1**

Aim of the course

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

Unit I

Soil biota, soil microbial ecology, types of organism's in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

Unit II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizosphere and PGPR.

Unit III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

Unit IV

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

Unit VI

Biofertilizers–definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

Unit VII

Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis–important mechanisms and controlling factors; soil genomics and bio prospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S oxidation, P solubilization and mineralization of other micronutrients; Study of rhizosphere effect

Teaching methods/activities

Classroom teaching with AVaids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil microbes and their utility in research for solving field problem.

Suggested Reading

- Burges A & Raw F. 1967. *Soil Biology*. Academic Press.
- McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel, Dekker.
- Metting FB. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.
- Elder, A. Paul Soil Microbiology, Ecology, and Biochemistry, 3rd Edition, Elsevier
- Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.
- Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill. 91
- Stotzky G &Bollag JM. 1993. *Soil Biochemistry*. Vol. VIII. Marcel,Dekker.
- Sylvia DN. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.
- Wild A. 1993. Soil and the Environment - An Introduction. Cambridge, Univ. Press.
- P. K. Chhonkar , S. Bhadraray , A. K. Patra .2007. Experiments in soil Biology and Biochemistry, westville publishing house
- NirupamaTyagi . Soil Biochemistry.(Black Prints Publ.)
- Paul EA and Clark FE. Soil Microbiology and Biochemistry.
- Lynch JM. *Soil Biotechnology*
- Willey JM, Linda M. Sherwood and Woolverton CJ. *Prescott's Microbiology*.
- NS Subba Rao. 1986. *Biofertilizers in Agriculture*. Oxford & IBH pub. Co., New Delhi
- Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.
- Tate, R. L. (2000), *Soil Microbiology. IInd edition, John Wiley and Sons, New York*
- *Soil Microbiology and Biochemistry. 2nd Edition* Paul and Clark 1996. Academic Press.
- Yawalkar KS, Agarwal JP and Bokde S *Manures and Fertilizers.*
- Chhonkar, P. K., Bhadraray, S., Patra, A. K. and Purakayastha, T. J. (2007), *Experiments in Soil Biology and Biochemistry pp. 182*, Westville Publishing House, New Delhi.

Teaching Schedule

Theory

Sr. No.	Lecture No.	Topics to be covered	Weightage In %
I	1, 2	Definition of soil biology and soil biochemistry, Soil biota, Soil microbial ecology, Types of organisms in different soils, Significance of soil biota in soil quality	5
	3, 4	Soil microbial biomass and factors regulating SMB, Microbial interactions, Un- culturable soil biota	8
II	5, 6	Microbiology and biochemistry of root- soil interface, Phyllosphere, Soil characteristics influencing growth and activity of micro flora	7
	7, 8, 9	Enzymes in soils – origin, distribution, activities, and their importance in soil quality, Root rhizosphere and PGPR	8
III	10, 11	Microbial transformations of nitrogen and phosphorus	7
	12, 13, 14	Microbial transformations of sulphur, iron and manganese in soil	8
	15, 16	Biochemical composition and biodegradation of soil organic matter and crop residues, Microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials	8

	17, 18, 19	Cycles of important organic nutrients (C, N, S & P)	10
IV	20, 21	Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures	4
	22, 23	Biotic factors in soil development, Microbial toxins in soil	5
V	24, 25, 26	Preparation and preservation of farmyard manure, animal manure, rural and urban compost and vermicompost	5
VI	27, 28, 29	Biofertilizer – definition, classification and specifications, Method of production of biofertilizers and their roles in crop production, FCO specification and quality control of biofertilizers	8
VII	30, 31, 32	Biological indicators of soil quality, Bioremediation of contaminated soils, Microbial transformation of heavy metals in soil	7
	33, 34	Role of soil organisms in pedogenesis- important mechanisms and controlling factors, Soil genomics and bioprospecting	5
	35, 36	Soil sickness due to biological agents, Xenobiotics, Antibiotic production in soil	5
			100

Practical

Sr. No.	Exercise No.	Topics to be covered
1	1, 2	Determination of soil microbial population by Serial Dilution Plate Technique
2	3, 4	Determination of soil microbial biomass carbon by Fumigation-Extraction Method
3	5	Determination of soil microbial biomass nitrogenby Fumigation-Extraction Method
4	6, 7	Fractionations of organic matter and functional groups
5	8	Monitoring organic matter decomposition in soil through CO_2 evaluation by Alkali Trap Method
6	9, 10, 11	Determination of soil enzymes - Urease, Dehydrogenase and phosphates
7	12	Measurement of ammonification
8	13	Determining nitrifying potential (nitrification) of soil
9	14	Measurement of N_2 fixation
10	15	Measurement of S oxidation
11	16	Measurement of P solubilization
12	17	Mineralization of micronutrients
13	18	Study of rhizosphere effect

Course Title :Radioisotopes in Soil and Plant Studies
Course Code :SOIL 507
Credit Hours :1+1

Aim of the course

To train students in the use of radioisotopes in soil and plant research.

Theory

Unit I

Atomic structure, radioactivity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

Unit II

Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography

Unit III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, iontransport,rootingpatternandfertilizeruseefficiency;carbondating

Unit IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half-life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radio isotopes
- Determination of A, E and L values of soil using 32P/65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15 N enrichment by mass spectrophotometry/ emission spectrometry

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of radioactivity and their utility in research for solving field problems.

Suggested Reading

- Comer CL.1955. *Radio isotopes in Biology and Agriculture: Principles and Practice*. Tata McGraw Hill.
- Glasstone S.1967. *Source Book on Atomic Energy*. East West Press.
- Michael FL and Annunziata.2003. *Handbook of Radioactivity Analysis*. Academic Press.

Teaching Schedule

Unit	No. of Lecture (s)	Topic	Weightage %
I	1&2	Atomic structure, radio activity and units;	04
	3&4	Radio isotopes- properties and decay principles;	08
	5	Nature and properties of nuclear radiations;	10
	6&7	Interaction of nuclear radiations with matter, artificial radioactivity	10
II	8 & 9	Principles and use of radiation monitoring instruments- Proportional,	10
	10 &11	Geiger Muller counter, solid and liquid scintillation counters;	10
	12 &13	Neutron moisture meter, mass spectrometry, auto radiography	10
III	14	Isotopic dilution techniques used in soil and plant research;	10
	15 &16	Use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating	12
IV	17	Doses of radiation exposure, radiation safety aspects regulatory aspects,	08
	18	Collection, storage and disposal of radioactive wastes	08
		Total	**100**

Practical's

Sr.No	Exercise No.	Name of Practical
1.	1, 2 & 3	Storage and handling of radioactive materials
2.	4, 5 & 6	Determination of half-life and decay constant
3.	7-8	Determination of fertilizer use efficiency by using radio isotopes
4.	9-10	Determination of cation exchange equilibria using radio isotopes
5.	11	Determination of A values of soil using 32P/65Zn
6.	12	Determination of E values of soil using 32P/65Zn
7.	13	Determination of L values of soil using 32P/65Zn
8.	14-15	Use of neutron probe for moisture determination
9.	16	Sample preparation of 15 N enrichment by mass spectrophoto metry/emission spectrometry
9.	17-18	Measurement of 15N enrichment by mass spectrophoto metry/ emission spectrometry

Course Title :**Soil, Water and Air Pollution**
Course Code :**SOIL 508**
Credit Hours :**2+1**

Aim of the course

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

Unit I

Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPCB, MPCB standards and effect on plants, animals and human beings, Pollution Control Act, Policies

Unit III

Sewage and industrial effluents–their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit IV

Pesticides– their classification, behavior in soil and effect on soil microorganisms.

Unit V

Toxic elements–their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases–carbon dioxide, methane and nitrous oxide.

Unit VII

Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammonical nitrogen and phosphorus, heavy metal content ineffluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safeguard foodsafety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc**.** Visit to various industrial sites to study the impact of pollutants on soil and plants.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Management of soil and water pollution

Suggested Reading

- Lal R, Kimble J, Levine E and Stewart BA.1995. *Soil Management and Greenhouse Effect*. CRC Press.
- Middlebrooks EJ.1979. *Industrial Pollution Control*. Vol.I .*Agro-Industries* .John Wiley Interscience.
- Ross SM. *Toxic Metals in Soil Plant Systems* .John Wiley & Sons.
- Vesilund PA and Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.
- A.K. Singh & Alka Tomar K.K. Singh, Asha Juwarka, 2007. Air, Water and Soil Pollution , Kalyani Publishers.
- Saha : Soil Pollution and Emerging Threat to Agriculture, 2018 Jain Books and Periodicals
- Soil Pollutions from monitoring to Remediation's By Duarte 2018 Jain Books and Perodicals

Teaching Schedule
Theory

Sr. No.	Lecture No.	Topics to be covered	Weightage (%)
I	1, 2, 3	Pollution-definition, Agril. Pollution soil water and air pollution, causes, nature and its extent, Classification and Discussion	6
II	4, 5	Nature and sources of pollutants – pesticides, fertilizer, industrial, urban waste, acid rains and oil spills	6
	6	Pollution of soil, water and air, CPCB, MPCB standards, Pollution Control Act, Policies	5
	7, 8, 9	Effect of pollutants on plant, animals, microorganisms in soil, and human beings	10
III	10, 11	Sewage and industrial effluents-definition, composition, properties and their extent	7
	12, 13, 14, 15	Sewage and industrial effluents, their effect on soil, water and air and plants and human being, Microorganisms soil as sink for waste disposal their methods merits and demerits	12
IV	16, 17, 18	Pesticides definition, classification, degradation behaviour in soil, water and air. Their effect on soil properties and microorganisms	12
	19	**Midterm examination**	
V	20, 21, 22, 23, 24	Toxic elements in pollutants, their hazardous effects on plant growth, human health, effect on soil available elements, microbial population.	12
VI	25, 26, 27	Effect of pollutants on water resources due to leaching of nutrients and pesticides from soil.	8
	28, 29, 30, 31	Effect of pollutants on emission of greenhouse gases, their extents, nature and effect on environment	10
VII	32, 33, 34	Use of improved techniques such as dilution, degradation, incineration, concentration, filtration, land disposal etc. nature and extents, merits and demerits	8
	35, 36	Remote sensing definition, scope in agriculture, and its use in monitoring and management of soil and water pollution	4
		Total	**100**

Practical

Sr. No.	Exercise No.	Topics to be covered
1	1	Visit to various industry to study the nature and impact on soil and plant
2	2, 3	Sampling of sewage water, sewage sludge soilid / liquid industrial waste, polluted soil and plant
3	4	Estimation of dissolved and suspended solids in liquid pollutant and pH, EC of solid samples
4	5, 6	Estimation of BOD (Biological) and COD (chemical oxygen demand) of liquid waste.
5	7, 8	Estimation of nitrate and ammonical nitrogen, phosphorus in sample
6	9, 10	Estimation of heavy metal in effluents
7	11, 12, 13	Estimation of heavy metals in soil and plants
8	14, 15	Management of contaminants in soil and plants to safe guard food safer
9	16	Collection of air sample
10	17	Determination of particulate matter in air samples
11	18	Determination of sulphur,NO_2 and O_2 in air sample

Course Title :Remote Sensing and GIS Technique for Soil and Crop Studies
Course Code :SOIL 509
Credit Hours :2+1

Aim of the course

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to Krigging, Remote Sensing and GIS and applications in agriculture.

Theory

Unit I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system(GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyper spectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System(ARIS).

Practical

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

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of remote sensing and their utility in research for solving field problem.

Suggested Reading

- Elangovan K.2006. *GIS Fundamentals, Applications and Implementations* .New India

Publl. Agency.
- Lillesand TM and Kiefer RW.1994. *Remote Sensing and Image Interpretation*. 3rdEd. Wiley.
- Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statis*tics. Catena Verloggmbh.
- Star J and Esles J.1990. *Geographic Information System: An Introduction* .Prentice Hall.
- Sahu , D.D. and R.M. Solanki : Remote Sensing Technique in Agriculture. Supply Services : M/S International Books & Periodicals
- Patel A.N ,Remote Sensing Principal and Application 3rd Editions by Supply Services : M/S International Books & Periodicals
- D.D. Sahu 2018 Agro metrology and Remote sensing principal and practices by International Books & Periodicals.

Teaching Schedule

Unit No.	L. No.	Topic	Weight age (%)
I	1-3	Introduction and history of remote sensing: Meaning and Definition Remote sensing, Types of Remote sensing and stages.	10
	4-6	Sources: Electromagnetic spectrum and radiation, propagation of radiations in atmosphere; interactions of electromagnetic radiation with atmosphere and earth surface:, spectral reflectance of soil water leaf and vegetation,	8
	7-9	principles and basic concepts of Remote sensing	8
	10-12	Hardware and software requirements for remote sensing	8
	13-15	Common terminologies of geographic information system (GIS)	8
II	16-18	Remote sensing Sensor systems-camera, platform, microwave radio meters and scanners;	10
	19-21	Fundamentals of aerial photographs and multispectral imaging, hyper spectral imaging, thermal imaging; image processing and interpretations	8
		MID TERM	
III	22-25	Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting,	8
	26-28	Prioritization in watershed and drought management, waste land identification and management	8
IV	29-30	Significance and sources of the spatial and temporal variability in soils;	8
	31-33	Variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.	8
V	34-36	Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).	8

Practical

Ex. No.	Name of practical Exercise
1	Determination of NDVI by using spectral refractometer
2	Determination of spectral indices by using spectro radiometer
3	To study the different type of soil survey

4	Preparation of base map by using Survey of India topo sheet
5-8	Interpretation of aerial photograph and satellite data for mapping of land resources
9-12	Analysis of variability of different soil properties with classical and geospatial techniques
13-14	Creation of data file in data base Programme by using GIS technique
15-16	Use of GIS for soil spatial simulation and analysis
17-18	To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

Course Title : Analytical Technique and Instrumental methods in Soil and Plant Analysis
Course Code : SOIL 510
Credit Hours : 0+2

Aim of the course

To familiarize the students with commonly used instruments–their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

Unit I

Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complex o metric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption,flame-photometry, inductively coupled plasmaspectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometry; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electro chemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/ di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

Teaching methods/activities

Classroom teaching and laboratory practical's

Learning outcome

Development of confidence and Skill for setting soil testing laboratory.

Suggested Reading

- Tandon HLS.2017. Method of Analysis of Soils, Plants, Water, Fertilizers & Organic Manures. FDCO, New Delhi.
- Hesse P.971.*Textbook of Soil Chemical Analysis* .William Clowes & Sons.
- Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
- Keith A Smith1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
- Kenneth Helrich1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.

- Page AL, Miller RH and Keeney DR.1982. *Methods of Soil Analysis*. PartII. SSSA, Madison.
- Piper CE. *Soil and Plant Analysis*. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN.1999. *Soil Plant Water Analysis-A Methods Manual*. IARI, New Delhi.
- Tan KH.2003. *Soil Sampling, Preparation and Analysis*. CRC Press/ Taylor & Francis.
- Tandon HLS.1993. *Methods of Analysis of Soils, Fertilizers and Wat*ers. FDCO, New Delhi.
- Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

Practical's

Unit No	Exercise No.	Name of Practical
1.	1&2	Preparation of solutions for standard curves, indicators and standard solutions for acid-base; oxidation reduction and complex metric titration
	3&4	Soil, water and plant sampling techniques, their processing and handling.
II	5	Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium.
	6	Determination of phosphorus fixation capacities of soils.
	7	Determination of ammonium fixation capacities of soils.
	8	Determination of potassium fixation capacities of soils.
III	9 & 10	Principles of visible, ultra violet and infrared spectrophotometry,
	11 & 12	Principles of atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery;
	13 & 14	Identification of minerals by X-ray and by different methods.
	15	Principles and application of CHNS analyzer.
IV	16&17	Electro chemical titration of clays
	18	Estimation of exchangeable cations (Na, Ca, Mg, K);
	19	Estimation of root cation exchange capacity.
V	20	Wet digestion/fusion/ extraction of soil with aquaregia with soil for elemental analysis.
	21	Estimation of available nitrogen from soil
	22	Estimation of available phosphorus from soil
	23	Estimation of available potassium from soil
	24	Estimation of exchangeable Ca and Mg from soil
	25	Estimation of available sulphur from soil
	26	Estimation of DTPA extractable micronutrients from soil
	27	Estimation of available boron from soil
	28	Triacid / di-acid digestion of plant samples for analyzing nutrient content
	29	Estimation of total nitrogen from plant sample
	30	Estimation of total phosphorus from plant sample
	31	Estimation of total potassium from plant sample
	32	Estimation of total Ca and Mg from plant
	33	Estimation of total sulphur from plant
	34	Estimation of total Fe, Mn, Zn and Cu from plant
	35&36	Drawing normalized exchange isotherms; measurement of redox potential.

Course Title :Management of Problematic Soils and Water
Course Code :SOIL 511
Credit Hours :1 +1

Aim of the course

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

Theory

Unit I

Area and distribution of problem soils of India with special emphasis on Maharashtra—acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization ofsalt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic, calcareous and dry land soils.

Unit IV

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

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit VI

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

Practical

Characterization of acid, acid sulfate, salt- affected and calcareous soils, Determination of cations (Na+, K+, Ca++ and Mg++) in ground water and soil samples, Determination of anions (Cl^-, SO_4^-, CO_3^- and HCO_3^-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on solving field problem of problem soil and waters.

Suggested Readings

- Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

- Jurinak JJ. 1978. *Salt- affected Soils* .Department of Soil Science & Biometeorology. Utah State University
- USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.
- Tandon HLS .2014. Soil Health Management : Physical, Chemical, biological, environmental, intensive cropping, dryland farming, management of problem soils. FDCO, New Delhi.

Teaching Schedule

Unit	Lecture No	Title	Weightage (%)
I	1	Area and distribution of problem soils- acidic , saline, sodic and saline –sodic and physically degraded soils inIndia, and Maharashtra	2
	2	Origin and basic concept of problematic soils	3
		Factors responsible for the formation of soils	5
II	3	Morphological features of saline, sodic and saline sodic soils	5
		Characterization of salt affected soils- soluble salts, ESP, pH,	5
	4	Physical and chemical and microbiological properties of problem soils	7
III	5	Management of salt affected soils,	5
	6	Salt tolerance of crops-mechanism and rating, salt stress meaning and its effect on crop growth	5
	7	Monitoring of soil salinity in the field	3
	8	Management principles for sandy, clayey soils	5
	9	Management principles for red lateritic, Calcareous and dry land soils	5
		MIDTERM	
IV	10	Acid soils- nature of soil acidity, sources of soil acidity	5
	11	Effect on plant growth, lime requirement of acid soils	4
	12	Management of acid soils	5
	13	Biological sickness of soils and its management	5
V	14	Quality of irrigation water	4
		Management of brackishs water for irrigation	5
	15	Salt balance under irrigation	4
		Characterization of brackish waters, area and extent of brackish waters	5
	16	Relationship in water use and quality	5
VI	17	Agronomic/ Management practices in relation to problematic soils	5
	18	Cropping pattern for utilizing poor quality ground water	3
		Total	**100**

Practical

Sr. No.	Practical No.	PRACTICALS
1	1	Preparation of saturation paste extract of soils and determination of pH and EC

2	2-3	Characterization of acid, acid sulphate, salt – affected soil
3	4-5	Characterization of calcareous soils
4	6-7	Determination of cations (sodium and potassium) in ground water and soil samples
5	8-9	Determination of cations (calcium and magnesium) in ground water and soil samples
6	10-11	Determination of anions (chlorides and sulphates) in ground water and soil samples
7	12-13	Determination of anions (carbonates and bicarbonates) in ground water and soil samples
8	14-15	Determination of lime requirement of acid soils
9	16-17	Determination of gypsum requirement of sodic soils
10	18	Visit to salt affected soils of command area

Course Title :Land Degradation and Restoration
Course Code :SOIL 512
Credit Hours :1+0

Aim of the course

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

Theory

Unit I

Type, factors and processes of soil/ land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit II

Land restoration and conservation techniques- erosion control, reclamation of salt-affected soils; mineral and reclamation, afforestation, organic products.

Unit III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, landuse policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on restoration of degraded soil for optimization of crop yield.

Suggested Reading

- Biswas TD and Narayanasamy G.(Eds.). 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Soc. Soil Sci.17, New Delhi.
- Doran JW and Jones AJ.1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.
- Greenland DJ and Szabolcs I.1994. *Soil Resilience and Sustainable Land Use*. CABI.
- Lal R, Blum WEH, Vailentine C and Stewart BA.1997. *Methods for Assessment of Soil Degradation*. CRC Press.
- Sehgal J and Abrol IP.1994. *Soil Degradation in India- Status and Impact*. Oxford & IBH.
- Tandon HLS. 2014. Soil Health Management : Physical, Chemical, biological, environmental, intensive cropping, dryland farming, management of problem soils. FDCO, New Delhi.
- Pal D.K.2019.Simple Methods to Study Pedology and Edaphology of IndianTropical Soils. *Springer*
- Applied Pedology 2014 by Deepak Sarkar and Abhijit Haldar Today and tomorrows Printers and Publishers

Teaching Schedule

Sr. No.	Lecture No	Title	Weight age (%)
I	1-2	Type, factors and processes of soil/ land degradation and its impact on soil productivity	10
	3-4	Soil Fauna, Biodegradation and environment	10
II	5-6	Land restoration and conservation techniques-erosion control	10
	7-8	Reclamation of salt-affected soils	10
	8-9	Mine land reclamation, afforestation, organic products	10
		Midterm Exam	
III	10-11-12	Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools	10
	13-14	Monitoring land degradation by fast assessment, modern tools,	10
	15	Landuse policy	10
	16-17	Incentives and participatory approach for reversing land degradation	10
	18	Global issues for twenty first century	10
			100

Course Title : Soil Survey and Landuse Planning
Course Code : SOIL 513
Credit Hours : 2+0

Aim of the course

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/ excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

Unit I

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

Unit II

Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Unit III

Concept and techniques of land use planning; factors governing present land use; Land evaluation method and soil- site suitability evaluation for different crops; land capability classification and constraints in application.

Unit IV

Agro-ecological regions/ sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

Practical

- Soil Survey by using RS and GIS, Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Landuse planning exercises using conventional and R Stools

Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit and exposure visit

Learning outcome

Planning for landuse in proper way for higher crop productivity.

Suggested Reading

- Sehgal J.2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J.2002. *Pedology-Concepts and Applications*. Kalyani.
- Boul SW, Hole ED, MacCraken RJ and Southard RJ. 1997. *Soil Genesis and Classification.* 4thEd. Panima Publ.
- Brewer R.1976. *Fabric and Mineral Analysis of Soils*. John Wiley & Sons.

- Rattan, J.C. Katyal, B.S. Dwivedi, A.K.Sarkar and T. Bhattacharrya J.C.Tarafdar and S.S.Kukal ; 2020 Soil Science and Introduction Indian Society of Soil Science
- T. Bhattacharyya 2021, Soil Studies Now and Beyond, Walnut publication new Delhi
- T. Bhattacharyya 2021, Information Systems and Ecosystems Services: Soil as Examples Walnut publication New Delhi
- Soil Series of Maharashtra 1999, NBSS & LUP ICAR, Nagpur
- Soil Survey Manual 2009 NBSS & LUP ICAR, Nagpur
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- USDA.1999. *Soil Taxonomy*. Hand Book No.436. 2ndEd. USDANRCS, Washington.

Teaching Schedule

Unit No.	Lecture No.	Topic	Weight age (%)
I	1	Soil survey, type of soil survey.	8
	2	Soil survey techniques :conventional and modern ,	8
	3	Soil series–characterization and procedure for establishing soil series; benchmark soils and soil correlations	10
	4-5	Soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for generation of soil maps by using remote sensing and GIS in soil survey and mapping of major soil group of India	10
II	5-6	Landform–soil relationship; major soil groups of India with special reference to Maharashtra states;	10
	7-8	land capability classification and land irrigability classification	6
	9-10	land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem	6
		MID TERM	
III	11	Concept and techniques of land use planning	10
	12	Factors governing present land use;	10
	13	Methods of land evaluation, Qualitative and quantitative.	6
	14-15	Soil-site suitability evaluation for different crops special emphasis to Maharashtra	4
	16	Land capability classification and constraints in application	10

IV	17	Agro-ecological regions/sub-regions of Maharashtra and India ,their characteristics in relation to crop production	10
	18	Status of LUP in India based on Agro-ecological regions/sub-regions of India	10
			100

Practical

Ex. No.	Name of practical Exercise
1	Preparation of base map by using survey of India toposheet
2	Preparation of base map by using satellite data
3	Preparation of base map by using Aerial photograph
4-5	Preparation of land use land cover map by using GIS and remote sensing technique.
6-7	Preparation of Physiographic map by using survey of India toposheet
7-8	Soil survey and data interpretation by using GIS and remote sensing technique
9	Processing of field sheet, compilation and obstruction of maps in different scales
10-15	Preparation of soil site suitability map
16	Preparation of land capability map
17	Preparation of land irrigability map
18	Development of land use plan by using conventional, GIS and remote sensing application

Course Title :Introduction to Nanotechnology
Course Code :SOIL 514
Credit Hours :2+1

Aim of the course

To impart basic knowledge about Nano science, properties of nanoparticles and their applications in biology

Theory

Unit I

General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, anisotropy.

Unit II

Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nanotubes and nanowires, fullerenes (buckballs, graphene). Nano fabrication and nano-patterning: Optical, X-ray, and electron beamlithography, self-assembled organic layers, process of synthesis of nanopowders, electro deposition, important nano materials.

Unit III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano particles, investigating and manipulating materials in the nanoscale: Electron microscopy

Unit IV

Nano-biology: Interaction between biomolecules and nano-particle surface, different types ofi norganic materials used for the synthesis of hybrid nano-bioassemblies, application of nano- in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

Practical

- Sources of nanoparticles and its preparation by different approaches
- Electro spinning and its use in agriculture and allied sector.
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nano technology.
- Synthesis and characterization of Ag and ZnO nano particles.
- Mode of action of ZnO nano particles against soil borne diseases

- Study on efficacy of ZnO nanoparticles as seed treating agent on plant growth parameters.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of nano science and their utility in research for solving field problem.

Suggested Reading

- Balandin AA and Wang KL.2006. *Handbook of semiconductor nanostructures and nanodevices*. California: American Scientific Publishers.
- Timp G.1999. *Nanotechnology*. New York: Springer Verlag.
- Challa Kumar SSR.2006. *Nanotechnologies for the life sciences*. Weinheim: Wiley-VCH GmbH.
- Kohler Mand Frintzsche W.2007. *Nanotechnology: Introduction to nanostructuring techniques* W Weinheim: Wiley-VCH Verlag GmbH.
- Kosal ME.2009. *Nanotechnology for chemicao and biological defense*. Dordrecht: Stringer.
- Panpatte Deepak G., Jhala Y.K. (2019) Nanotechnology For Agriculture: Crop Production And Protection.
- Panpatte Deepak G., Jhala Y.K. (2019) Nanotechnology For Agriculture: Advance For Sustainable Agriculture.
- Tadapdar J.C. Nanofertilizers Challenges and Prospects WWW// Scintific pub.com

Teaching schedule

Unit No.	Lecture No.	Topic	Weightage %
I	1, 2	Definition of nano technology, Importance of nano technology in agriculture	5
	3, 4	General introduction of nano technology, Properties of nano technology	8
	5, 6, 7	Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids	7
	8, 9, 10	Mössbauer effect and spectroscopy, optical phenomena, bond in solids, anisotropy	8

II	11, 12, 13, 14	Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nanotubes and nanowires, fullerenes (buckballs, graphene)	12
	15, 16, 17, 18, 19	Nano fabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nanopowders, electrode position, important nano materials	12
		Mid Term	
III	20, 21	Mechanical properties, magnetic properties	8
	22, 23, 24, 25, 26, 27	Electrical properties, electronic conduction with nanoparticles, investigating and manipulating materials in the nanoscale: Electron microscopy	10
IV	28, 29, 30	Nano-biology: Interaction between biomolecules and nano-particle surface	10
	31, 32, 33	Different types of inorganic materials used for the synthesis of hybrid nano-bioassemblies	10
	34, 35, 36	Application of nano- in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors	10
			100

Practicals

Exercise No.	**Topic**
1, 2	Study of sources of nanoparticles and its preparation by different approaches
3, 4	Electro spinning and its use in agriculture and allied sector
5	Equipment’s used in Nanotechnology: its principle and uses
6, 7	Acquaintances with different equipment’s used in nano technology
8, 9, 10	Synthesis and characterization of Ag nano particles
11, 12, 13	Synthesis and characterization of ZnO nano particles
14, 15	Mode of action of ZnO nano particles against soil borne diseases
16, 17, 18	Study on efficacy of ZnO nano particles as seed treating agent on plant growth parameters

Ph.D. (Agriculture) in Soil Science
Course Plan and Layout

Course No	Title of Course	Credit	Remark
Semester I			
SOIL 601	Recent trends in Soil Physics	(2+0)	Major
SOIL 603*	Physical Chemistry of soil	(2+0)	Major
SOIL 604*	Soil genesis and micro morphology	(2+0)	Major
AGRON 602	Recent trends in crop growth and productivity	(2+1)	Minor
PP 606	Global Climate Change and Crop Response	(2+0)	Supporting
		11	
Semester II			
SOIL 602	Modern concept in soil fertility	(2+0)	Major
SOIL 610	Bio-chemistry of soil organic matter	(2+0)	Major
AGRON 606	Soil Conservation and Watershed Management	(2+1)	Minor
AGRO/HORT/BOT/ BIOCHEM/STAT	Relevant to student Research	(3)	Supporting
	OR		
BIOCHEM-603	Biochemistry of Biotic and Abiotic Stress	(3+0)	Supporting
		10	
Semester III			
SOIL 606	Soil resource management	(3+0)	Major
SOIL 691	Doctoral seminar	(1+0)	Seminar
SOIL 699	Doctoral Research	(0+10)	
		14	
Semester IV			
SOIL 692	Doctoral seminar	(1+0)	Seminar
SOIL 699	Doctoral Research	(0+25)	
Total			
Semester V			
SOIL 699	Research	(0+25)	
Semester VI			
SOIL 699	Research	(0+15)	
Total		100	
Major 13 + Minor 06+ Supporting 05 + Seminar 02+ Research 75 = 101			

Ph.D. (Agri.) in Soil Science Course Content

Course Title :Recent Trends in Soil Physics
Course Code :SOIL 601
Credit Hours :2+0

Aim of the course

To provide knowledge of modern concept in soil physics.

Theory

Unit I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant-atmospheric continuum (SPAC). Relation of conductivity and permeability to pore geometry, Boltzman Transformation.

Unit II

Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.

Unit III

Theories of horizontal and vertical infiltration under different boundary conditions.

Unit IV

Movement of salts in soils, and salt balance, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

Unit V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil; Soil, Plant, Water relations-Plant uptake of soil moisture, Water balance and energy balance in the field; irrigation and water use efficiency.

Unit VI

Soil crust and clod formation; structural management of puddle rice soils; soil conditioning- concept, soils conditioners- types, characteristics, working principles, significance in agriculture.

Unit VII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Reading

- Baver LD, Gardner WH and Gardner WR.1972. *Soil Physics* .John Wiley & Sons.
- Hanks and Ascheroft.1980.*Applied Soil Physics*. Springer Verlag.
- Hillel D.1980. *Applications of Soil Physics*. Academic Press.
- Hillel D.1980. *Environmental Soil Physic*s. Academic Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL.1972. *Advanced Soil Physics*. Wiley Interscience.
- Lal R and Shukla MK.2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC.1994. *Soil Physics* .Oxford & IBH.
- Text book of soil physics by Arun Kumar Saha, Anuradha Saha. Kalyani Publication New Delhi
- Soil Physics An Introduction By Manoj K. Shukla Published December 2, 2013 by
- CRC Press 478 Pages 201 B/W Illustrations
- Principles of Soil Physics By Rattan Lal, Manoj K. Shukla. Published September 27, 2019 by CRC Press 736 Pages
- Applications of Soil Physics 1st Edition - October 28, 1980 Daniel Hillel Elsevier

Teaching Schedule
Theory

Unit No.	**Lecture No.**	**Topics to be covered**	**Weightage %**
I	1& 2	Soil – water interaction, soil water potential.	3

	3 & 4	Free energy and thermodynamic basis of potential concepts.	4
	5 &6	Chemical potential of soil water entropy of the system. Soil-Plant-Atmospheric Continuum (SPAC).	4
	7	Relation of conductivity and permeability to pore geometry, Boltzman Transformation.	4
II	8&9	Fundamentals of fluid flow, Poiseuilles law, Laplace's equation.	4
	10&11	Darcy's law in saturated and unsaturated flows,	5
	12	Development of differential equations in saturated and unsaturated water flow.	5
	13&14	Capillary conductivity and diffusivity; limitations of Darcy's law numerical solution for one dimensional water flow	3
III	15 & 16	Theories of horizontal and vertical infiltration under different boundary conditions.	5
IV	17 & 18	Movement of salts in soils, Leaching of excess salts, combined transport of solutes, effect of solutes on water movement	5
	19	Models for miscible-immiscible displacement,	3
	20 & 21	Diffusion, mass flow and dispersion of solutes and their solutions through differential equations, break through curves.	5
V	22	Soil air and aeration, mass flow and diffusion processes	3
	23	Soil respiration and aeration requirements	4
	24	Thermal properties of soil, heat transfer in soils, differential equation of heat flow.	4
	25	Measurement of thermal conductivity of soil.	4
	26	Soil, Plant, Water relations- Plant uptake of soil moisture,	4
	27	Water balance and energy balance in the field; irrigation and water use efficiency.	4
VI	28	Soil crust and clod formation	4
	29	Structural management of puddled rice soils.	4
	30 & 31	Soil conditioning concept, soils conditioners- types, characteristics, working principles, significance in agricultures.	5
VII	32&33	Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems.	5
	34& 35	Prediction of evapotranspiration using aerodynamic and canopy temperature-based models	5
	36	Canopy temperature and leaf diffusion resistance in relation to plant water deficit, evaluation of soil and plant water status using infra-red thermometer.	4
			100

Course Title :**Modern Concept in Soil Fertility**
Course Code :**SOIL 602**
Credit Hours :**2+0**

Aim of the course

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

Unit I

Nutrient availability-concept and relationships, modern concepts of nutrients availability; soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients, soil solution and plant growth; nutrient response functions and availability indices.

Unit II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

Unit III

Chemical equilibria (including solid- solution equilbria) involving nutrientions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils.

Unit IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

Unit V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

Unit VI

Monitoring physical, chemical and biological changes in soils; permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use. Conservation agriculture

Unit VII

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

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Reading

- Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley & Sons.
- Barker V Allen and Pilbeam David J.2007. Handbook of Plant Nutrition. CRC/ Taylor & Franc
- Brady NC and Weil RR.2002. *The Nature and Properties of Soils*. 13thEd. Pearson Educ.
- Cooke GW.1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.
- Epstein E.1987. *Mineral Nutrition of Plants-Principles and Perspectives*. International Potash Institute, Switzerland.
- Kabata-Pendias Alina2001. *Trace Elements in Soils and Plants* .CRC/ Taylor & Francis.
- Kannaiyan S, Kumar K and Govindarajan K.2004. *Biofertilizers Technolo*gy. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. (Eds.).1991. *Micronutrients in Agriculture.* 2ndEd. Soil Science Society of America, Madison.
- Prasad R and Power JF.1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Stevenson FJ and Cole MA.1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur,*
- *Micronutrients.* John Wiley & Sons.
- Stevenson FJ.(Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL.1990. *Soil Fertility and Fertilizers 5th* Ed. Macmillan Publ.
- Wild A. (Ed.).1988. *Russell's Soil Conditions and Plant Growth*. 11thEd. Longman.
- HLS Tondon, Fertilizers in Indian Agriculture-from 20th to 21st century 2004,FDCO

Sohna Road Gurgaon122018.

- HLS Tondon ,Soil Fertility, Fertilizers and INM 2011 FDCO Sohna Road Gurgaon 122018
- Jaja Pravin Kukar Bharat Singh, Soil Fertility Fertilizers and Agrochemicals, ASTRAL International Publication Ptd.
- HLS Tondan, Fertilizer management balance efficiency and profitability , 2012,

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1	Nutrient availability- concept and relationships Modern concept of nutrient availability. soil colloids and nutrient availability; soil amendments and availability maintenance of nutrients	8
	2 & 3	Soil solution and plant growth nutrient response.	5
	4	Functions and availability indices.	5
II	5 & 6	Nutrient movement in soils, nutrient absorption by plants.	5
	7 & 8	Mechanisms approach to nutrient supply and uptake by plants; models	6
	9 & 10	Transformation and movements of major and micronutrients in soil	7
III	11 & 12	Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soil particularly submerged soils. Kinetic studies	6
IV	13 & 14	Modern concept of fertilizer evaluation, nutrient use efficiency and nutrient budgeting	6
V	15 & 16	Modern concept in fertilizer application, methods.	6
	17 & 18	Soil fertility evolution techniques	8
	19	Role of soil test in fertilizer use recommendations	5
	20	Site specific nutrient management for precision agriculture.	5
VI	21 & 22	Monitoring physical, chemical and biological changes in soils.	6
	23 & 24	Permanent manurial trails and long term fertilizer experiments	5
	25 & 26	Soil productivity and long-term intensive cropping, direct, residual and cumulative effect of fertilizer use. Conservation Agriculture	6
	27 & 28	Carbon–a nutrient central to soil fertility; carbon cycle in nature, stocks, pools and fluxes	6
	29 & 30	Greenhouse effect and climate change; carbon sequestration vis-à-vis sustenance of soil quality and crop productivity. Natural Farming	5
			100

Course Title :Physical Chemistry of Soil
Course Code :SOIL 603
Credit Hours : 2+0

Aim of the course

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

Unit I

Colloidal chemistry of inorganic and organic components of soils–their formation, clay organic interaction.

Unit II

Predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL)- relationships among different selectivity coefficients; structure and properties of diffuse double layer.

Unit III

Thermodynamics of nutrient transformations in soils; Climate change effects on mineralogy and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction.

Unit IV

Adsorption/ desorption isotherms-Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

Unit V

Common solubility equilibria- carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electro chemical properties of clays (citation of examples from agricultural use).

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil chemical behavior on research for solving field problems.

Suggested Reading

- Bear RE.1964. *Chemistry of the Soil.* Oxford & IBH.
- Bolt GH and Bruggenwert MGM.1978. *Soil Chemistry*. Elsevier.
- Fried M and Broeshart H.1967. *Soil Plant System in Relation to Inorganic Nutrition.* Academic Press.
- Greenland DJ and Hayes MHB.1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB.1978. *Chemistry of Soil Constituents*. John Wiley &

Sons.

- Jurinak JJ.1978. *Chemistry of Aquatic Systems*. Department of Soil Science and Biometeorology, Utah State University
- McBride MB.1994. *Environmental Chemistry of Soils*. Oxford University Press.
- Sparks DL.1999. *Soil Physical Chemistry*. 2ndEd. CRC Press.
- Sposito G.1981. *The Thermo dynamics of Soil Solutions*. Oxford University Press.
- Sposito G.1984. *The Surface Chemistry of Soils* .Oxford University Press.
- Sposito G.1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ.1994. Humus Chemistry. 2nd Ed. John Wiley.
- VanOlphan H.1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.
- Donald L. Sparks, Soil Physical Chemistry, Second Edition 1998 edited by CRC Press available E Book Text book of soil physics by Arun Kumar Saha, Anuradha Saha Kalyani Publication New Delhi
- Hanks and Ascheroft.1980.*Applied Soil Physics*. Springer Verlag.
- Hillel D.1980. *Applications of Soil Physics*. Academic Press.
- Hillel D.1980. *Environmental Soil Physic*s. Academic Press.
- Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL.1972. *Advanced Soil Physics* .Wiley Interscience.
- Lal R and Shukla MK.2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC.*1994. Soil Physics. Oxford & IBH.*
- Soil Physics An Introduction By Manoj K. Shukla Published December 2, 2013 by
- *CRC Press 478 Pages 201 B/W Illustrations*
- *Principles of Soil Physics*. Rattan Lal, Manoj K. Shukla Published September 27, 2019 by CRC Press 736 Pages
- *Applications of Soil Physics* 1st Edition - October 28, 1980 Daniel Hillel Elsevier
- *Soil Physical Chemistry, Second Edition 1998 edited by* Donald L. Sparks, CRC Press
- available E Book

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage %
I	1& 2	Colloidal chemistry of inorganic components of soils their formation.	8
	3 & 4	Colloidal chemistry of Organic components of soils their formation	8

	5	Clay organic interaction	5
II	6 & 7	Predictive approaches for cation exchange equilibria	4
	8 & 9	Thermodynamics, empirical and diffuse double layer theory (DDL)	6
	10 & 11	Relationships among different selectivity coefficients	4
	12	Structure and properties of diffuse double layer.	5
III	13 & 14	Thermodynamics of nutrients transformation in soils	7
	15& 16	Climate change effects on mineralogy and surface properties of variable charge;	5
	17&18	Cationic exchange and their models, molecular interaction.	4
	18&19	Anionic exchange and their models, molecular interaction.	4
IV	20	Adsorption / desorption isotherms definitions and importance.	4
	21 &22	Langmuir adsorption isotherm, Freundlich adsorption isotherm	5
	23 &24	Normalized exchange isotherm, BET equation	5
	25&26	Selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agriculture system).	4
	27&28	Selective adsorption of ions on organic surfaces of soil materials (citation of utility in agriculture system).	4
	29&30	Non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials(citation of utility in agriculture system).	4
	31&32	Non-selective adsorption of ions and organic surfaces of soil materials (citation of utility in agriculture system).	4
V	33 & 34	Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate	5
	35&36	Electrochemical properties of clays (citation of examples from agriculture use.)	5
			100

Course Title :**Soil Genesis and Micromorphology**
Course Code :**SOIL 604**
Credit Hours :**2+0**

Aim of the course

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

Unit I

Pedogenic evolution of soils; soil composition and characterization.

Unit II

Weathering and soil formation–factors and pedogenic processes; stability and weathering sequences of minerals.

Unit III

Assessment of soil profile development by mineralogical and chemical analysis.

Unit IV

Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil micropedology and soil taxonomy on research for solving field problems.

Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13thEd. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ.1997. *Soil Genesis and Classification*. 4thEd. Panima Publ.
- Dixon JB and Weed SB.1989. *Minerals in Soil Environments*. 2ndEd. Soil Science Society of America, Madison.
- Grim RE.1968. *Clay Mineralogy*. McGraw Hill.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Sehgal J.2002. *Introductory Pedology: Concepts and Applications*. New Delhi
- Sehgal J.2002. *Pedology-Concepts and Applications*. Kalyani Publisher.
- USDA.1999. *Soil Taxonomy*. Hand Book No.436.2ndEd. USDA NRCS, Washington.
- Wade FA and Mattox R B.1960. *Elements of Crystallography and Mineralogy*. Oxford & IBH.
- Rattan, J.C. Katyal, B.S. Dwivedi, A.K. Sarkar and T. Bhattacharrya J.C.Tarafdar and S.S.Kukal ; 2020 Soil Science and Introduction Indian Society of Soil Science
- T .Bhattacharyya 2021, Soil Studies Now and Beyond, Walnut publication New Delhi
- T. Bhattacharyya 2021, Information Systems and Ecosystems Services : Soil as Examples Walnut publication New Delhi
- Soil Series of Maharashtra 1999, NBSS & LUP ICAR , Nagpur

- Soil Survey Manual 2009 NBSS & LUP ICAR , Nagpur
- Pal D.K.2019.Simple Methods to Study Pedology and Edaphology of Indian Tropical Soils. *Springer*
- Applied Pedology 2014 by Deepak Sarkar and Abhijit Haldar Today and tomorrows Printers and Publishers

Teaching Schedule

Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 & 2	Scope and significance of soil genesis and mircro-pedology.	10
	3 -5	Pedogenic evolution of soils.	10
	6-9	Soil composition and characterization.	10
II	10-12	Weathering and soil formation-factors and pedogenic processes.	10
	13	MIDTERM	
	14-16	Stability and weathering sequences of minerals.	10
III	17-19	Assessment of soil profile development by mineralogical and chemical analysis.	15
IV	20-23	Micro-pedological features of soils – their structures. Approaches to thin section description, basic concept and descriptive criteria.	15
	24-27	Fabric analysis: Micro structure, Basic mineral components, organic components, Ground mass, pedofeatures and their role in genesis and classification.	10
	28-32	Recent trends in Soil Genesis and Micropedology	10
			100

Course Title :**Biochemistry of Soil Organic Matter**
Course Code :**SOIL 605**
Credit Hours :**2+0**

Aim of the course

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

Unit I

Organic matter in soils and its maintenance. Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration.

Unit II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

Unit III

Nutrient transformation–N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

Unit IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes.

Unit V

Humus-pesticide interactions in soil, mechanisms.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience, Problems on the knowledge of soil Bio chemistry on research for solving field.

Suggested Reading

- Lynch JM, Willey JM. *Soil Biotechnology*.
- Paul EA and Clark FE. *Soil Microbiology and Biochemistry*
- Sherwood LM and Woolverton CJ. *Prescott's Microbiology*.
- Subba Rao NS. *Advances In Agricultural Microbiology*
- Kononova, MM and Mariya Kononova. Soil Organic Matter- Its Role In Soil Formation And Soil Fertility.
- HLS Tandon. Method of Analysis of Soils, Plants, Water, Fertilizers & Organic Manures. Revised and Reprinted 2017.
- The Rhizosphere: Biochemistry and Organic Substances at the Soil-Plant Interface, Second Edition (Books in Soils, Plants, and the Environment) Paperback – 23 September 2019 by Roberto Pinton (Editor), Zeno Varanini (Editor), Paolo Nannipieri (Editor) E Book

Teaching Schedule

Theory

Unit	No. of Lecture (s)	Topic	Weightage %
I	1&2	Organic matter in soils and its maintenance.	04
	3&4	Role of organic matter in soil productivity;	06
	5&6	Humus levels in soils.	02
	7&8	Current thinking on the maintenance of organic matter in the soils..	06
	9&10	Carbon retention and sequestration	06
II	11,12&13	Biochemistry of the humus formation;	06
	14,15&16	Different pathways for humus synthesis in soil;	08
	17,18&19	Soil carbohydrates and lipids.	06
III	20&21	Nutrient transformation– Nitrogen	06
	22&23	P transformation and S transformation	06
	24&25	Trace metal interaction with humic substances,	06
	26	Significance of chelation reactions in soils.	06
IV	27,28&29	Reactive functional groups of humic substances,	06
	30,31&32	Adsorption of organic compoundsby clay and role of organic substances in pedogenic soil aggregation processes;.	08
	33	Clay-organic matter complexes	06
V	34,35&36	Humus-pesticide interactions in soil, mechanisms.	10
		Total	**100**

Course Title :**Soil Resource Management**
Course Code :**SOIL 606**
Credit Hours :**3+0**

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation; soil conservation in hilly, arid, semi arid, coastal and drylands. Management of forest, peat and muck soils.

Unit IV

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

Unit V

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

Unit VI

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

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil resources on research for solving field problems.

Suggested Reading

- Abrol IP and Dhruvanarayana VV. 1990. *Technology for Wasteland Development*. ICAR, New Delhi.

- Andriesse JP. 1988. *Nature and Management of Tropical Peat Soils*, Soil Resources, FAO Soils Bulletin 59, Management and Conservation Service, Land and Water Development Division, FAO, Rome
- Blackwell, Dent D and Young A. 1981. *Soil Survey and Land Evaluation*. George Allen and Unwin, London.
- Burrough A and McDonnell RK.1998.*Principles of Geographical Information System*. Oxford University Press.
- Dan Binkley D and Fisher R.2012. *Ecology and Management of Forest Soils*, 4th Edition, Wiley.
- FAO.1996. *Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development*. FAO Land and Water Bulletin.5.FAO, Rome.
- Faroq Mand Siddique K.(Ed.).2015. *Conservation Agriculture*, Springer Nature, Chennai, India.
- FESL. 1993. *An International Framework for Evaluating Sustainable Land Management, FAO World Soil Resources Report No.73*, Land Development Division, FAO, Rome.
- ISSS. 1994. *Management of Land and Water Resources for Sustainable Agriculture and Environment*. Diamond Jubilee Symposium Publication, Indian Society of Soil Science, New Delhi.
- Lal R, Blum WEH, Valentine C and Stewart BA.(Editors).1988.*Methods for Assessment of Soil Degradation*.CRC Press, Boca Raton.
- Mulders MA.1987. *Remote Sensing in Soil Science*. Elsevier Science Publishers, Amsterdam.
- Sehgal J.2014. *A Text Book of Pedology Concepts and Application*. Kalyani publishers, New Delhi.
- SSSA 1996. *Methods for Assessing Soil Quality*. SSSA Publication Number 49, Madison, Wisconsin, USA.
- Rattan, J.C. Katyal, B.S. Dwivedi, A.K.Sarkar and T. Bhattacharrya J.C.Tarafdar and S.S.Kukal ; 2020 Soil Science and Introduction Indian Society of Soil Science
- T .Bhattacharyya 2021, Soil Studies Now and Beyond, Walnut publication New Delhi
- T. Bhattacharyya 2021, Information Systems and Ecosystems Services : Soil as Examples Walnut publication New Delhi
- Soil Series of Maharashtra 1999, NBSS & LUP ICAR , Nagpur
- Soil Survey Manual 2009 NBSS & LUP ICAR , Nagpur
- Soil Hydrology Land Use and Agriculture : Measurement and Modeling 2011, Shukala Publication : CABI (Techno Books and Periodicals)
- Land and soil Resources by BRAIMOH 2008 Springer
- Sustainable Management of Vertisols by SYERS ,2001 CABI
- Natural Resources and Sustainable Agricultural Management by D.N.Chakravatry 2016 Today and tomorrows Printers and Publishers
- Soil Resources of North Eastern States of India by Utpal Baruah , Anil Kumar Sahoo and Dipak Sarkar, Today and tomorrows Printers and Publishers
- Land Resource Inventory (LRI) ICAR NBSS & LUP

Teaching Schedule

Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 & 2	Relevance of soil management to sustainable agriculture;	5
	3-6	Soil Functions: soil as a natural resource for biomass	8

		production, filtering, buffering, transportation of solutes, genereserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases	
II	7-9	Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security;	8
	10-12	Soil quality indices	8
	13-15	Conservation agriculture in relation to soil quality;	7
	16-17	Soil resilience and resistance.	8
III	18	Types, factors and causes of land degradation and desertification;	5
	19-20	GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation;	8
	21-22	history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategies for erosion control and conservation;	8
	23-24	soil conservation in hilly, arid, semiarid, coastal and drylands. Management of forest, peat and muck soils.	8
		MIDTERM	
IV	25-28	Soil conservation planning; land capability classification; soil conservation in special problem are as such as hilly, arid and semi-arid regions, waterlogged and wetlands; land restoration and conservation techniques–erosion control,	8
	29-31	Reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation.	8
V	32-33	Watershed management-concept, objectives and approach; water harvesting and recycling;	8
	34-35	flood control in watershed management;	6
	36-38	socio-economic aspects of watershed management.	8
VI	39-40	Agro-ecological regions of India;, national and international soil policy considerations.	7
	41-42	potentials and constraints of soils of different regions;	8
	43-45	land evaluation and rationalizing land use	6
	46-48	decision support system with relation to land management;	8
	49-51	case studies in respect to monitoring and evaluation of watersheds	8

Course Title : Modelling of Soil Plant System
Course Code : SOIL 607
Credit Hours : 2+0

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis- Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on soil modeling concept for forecasting productivity

Suggested Reading

- Datta SC. 2008. *Theory and Principles of Simulation Modeling in Soil-Plant System*. Capital Publishing Company, New Delhi.
- Frame J and Thornley JHM. 1984. *Mathematical Models in Agriculture—A Quantitative Approach To Problems In Agriculture And Related Science*. Butterworth and Co. Ltd.
- Freud PJ and Minton PD.1979. *Regression Methods—A tool for data Analysis*. Marcel Dekker Inc., New York.
- Frissel MJ and Reinger P.1974. *Simulation of Accumulation and Leaching in Soils* .Oxford and IBM Pub. Co., New Delhi.
- Hanks J and Richie JT.(Eds.).1991.*Modeling Plant and Soil System*. Agronomy Bulletin No.31, ASA, SSSA Madison, Wisconsin, USA.
- Lipschutz S and Poe A.1978. *Schaum's Outline Series–Theory and Problems of programming with Fortran*. McGraw- Hill Book Co., Singapore.
- Penning deVries FWT, Jansen DM, Ten Berge HFM and Baker A.1989. *Simulation Of Ecophysiological Processes Of Growth In Several Annual Crops*. PUDOC, Wageningen.

- Shaffer MJ, MaL and Hansen S.2001. *Modeling Carbon and Nitrogen Dynamics for Soil Management*. Lewis Publishers, Boca Raton.
- T .Bhattacharyya 2021, Soil Studies Now and Beyond, Walnut publication New Delhi
- T. Bhattacharyya 2021, Information Systems and Ecosystems Services : Soil as Examples Walnut publication New Delhi

Teaching Scheduled
Theory

Unit No.	**Lecture No.**	**Topics to be covered**	Weightage in %
I	1	Introduction, terms and definitions;	8
	2 & 3	Classification of models; Taylor series;	8
	4,5 & 6	Numerical methods of differentiation and integration	8
II	7,8 &9	High level computer language	6
		FORTRAN-its commands and usage;	7
	10,11 &12	Testing and evaluation of model	8
III	13 &14	Description of spatially homogeneous models;	8
	15,16 &17	K transformation model; nitrogen and phosphorus dynamics in soil	8
IV	18,19 &20	Spatially heterogeneous models; equation of continuity; Simulation of waterflow through soil; Explicit and Explicit-Implicit method; simulation of solute movement through soil with variable moisture flux by explicit-implicit method	8
V	21, 22 &23	Nutrient uptake model	7
	24-,25,27,28&29	Integration of nutrient movement in soil (mass flow and diffusion)	8
	30,31 &32	Uptake by plants (Michaelis-Menten kinetics);	8
	33,34 ,35 &36	Nutrient uptake model: Solubility and free ion activity model.	8
			100

Course Title :**Clay Mineralogy**
Course Code :**SOIL 608**
Credit Hours :**2+1**

Aim of the course

To train the students in concepts, methodology, technology and use of Clay mineralogy in soil and crop studies

Theory

Unit I

Definition and concepts of clays and clay minerals, Fundamentals of crystallography – unit cell, notations, crystal systems. External characteristics of crystals, crystallographic weathering sequence and stability index of minerals.

Unit II

Structures and classification of silicate minerals, basics of phyllosilicates, laws governing structural characteristics of phyllosilicates, Goldschmitdt's laws–Law-I and Law-II, Classification of Phyllosilicates.

Unit III

Kaolonite group of minerals, Dioctahedral kaolins and Tri octahedral kaolins.

Unit IV

Smectites; properties of smectites, Reference models of structure, principal types based on Hofmann- Marshal- Hendricks (H-M-H) models, occurrence of smectites, transformation and formation in soils.

Unit V

Micas: occurrence and origin in soils, polytypes of micas, structure and formation of muscovites and illite.

Unit VI

Vermicullites: structure, occurrence in soils, formation, relation between vermiculites and montmorillonite.

Unit VII

Chlorite: occurrence and structure of chlorites,"swelling chlorites", formation of chlorite.

Unit VIII

Non-crystalline clays (amorphous materials), subgroups and chemical composition, morphology and structure, physico-chemical properties, influence of non-crystalline clays on soil properties.

Unit IX

Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals.

Unit X

Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit XI

Surface chemistry of clayminerals, clay-organic complexes, nanoclay mineralogy.

Unit XII

Clay minerals in different soil orders, role of clay minerals in soil fertility management. Assessment of soil profile development by mineralogical analysis.

Practicals

- Separation of clay for mineralogical study
- X-ray diffraction analysis of clay
- Selective dissolution of clay minerals
- IR, DTA and SEM of clay minerals
- Identification and quantification of clay minerals
- Determination of surface charge of clay minerals
- Potentiometric titration of clay minerals.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on soil clays and utility in soil research.

Suggested Reading

- Dixon JB and Weed SB (Co-editors). *Minerals in Soil Environment.*
- Gieseking JE (Ed). *Soil Component*, Vol.2. Inorganic Components.
- Grim RE. *Clay Mineralogy*.
- Mukherjee SK and Biswas TD (Editors). *Mineralogy of Soil Clays and Clay Minerals*.
- Read HH. *Rutley's Elements of Mineralogy*.
- Wilding LP and Smeck NE.1983. *Pedogenesis and Soil Taxonomy Part II– Soil Orders.*
- Pal D.K.2019. Simple Methods to Study Pedology and Edaphology of IndianTropical Soils. *Springer*

Teaching schedule

Theory

Unit	Lecture No.	Topic	Weightage %
I	1	Definition and concepts of clays and clay minerals	5
	2	Fundamentals of crystallography –unit cell, notations, crystal systems	5
	3	External characteristics of crystals, crystallographic	2.50
II	4	Structures and classification of silicate minerals, basics of phyllosilicates	5
	5	Laws governing structural characteristics of phyllosilicates	3.75
	6	Goldschmitdt's laws–Law-I and Law-II, Classification of Phyllosilicates,	3.75
	7	Weathering sequence and stability index of minerals	2.50
III	8	Kaolonite group of minerals and their properties	2.50
	9	Dioctahedral kaolins and Trioctahedral kaolins	3.75
IV	10	Smectites; properties of smectites	3.75
	11, 12	Reference models of smectites structure, principal types based on Hofmann-Marshal- Hendricks (H-M-H) models	5
	13, 14	Occurrence of smectites, transformation and formation in soils	2.50

V	15	Micas: occurrence and origin in soils	2.50
	16	Polytypes of micas, structure and formation of muscovites and illite	2.50
		Mid Term	2.50
VI	17	Vermicullites: structure, occurrence in soils	2.50
	18	Formation, relation between vermiculites and montmorillonite	2.50
VII	19	Chlorite: occurrence and structure of chlorites	2.50
	20	"Swellingchlorites", formation of chlorite	2.50
VIII	21	Non-crystalline clays (amorphous materials)	2.50
	22	Subgroups and chemical composition, morphology and structure of amorphous material	2.50
	23	Physico-chemical properties, influence of non-crystalline clays on soil properties	2.50
IX	24	Interstratified clay minerals, occurrence and formation in soils	3.75
	25	Regularly interstratified and partially random interstratified minerals	2.50
X	26, 27	Genesis and transformation of clay minerals	5
	28	Generalized conditions for formation and persistence of common clay-size minerals in soils	2.50
XI	29	Surface chemistry of clay minerals	3.75
	30, 31	Clay-organic complexes, nano clay mineralogy	3.75
XII	32, 33	Assessment of soil profile development by mineralogical analysis	5
	34, 35	Clay minerals in different soil orders	3.75
	36	Role of clay minerals in soil fertility management	2.50
			100

Practical

Practical No.	**Topic**
1, 2, 3	Separation of clay for mineralogical study
4, 5	X-ray diffraction analysis of clay
6	Selective dissolution of clay minerals
7, 8, 9	IR, DTA and SEM of clay minerals
10, 11, 12	Identification and quantification of clay minerals
13, 14, 15	Determination of surface charge of clay minerals
16, 17, 18	Potentio metric titration of clay minerals

Course Title :Recent Trends in Soil Microbial Biodiversity
Course Code :SOIL 609
Credit Hours :2+1

Aim of the course

To train the students in concepts, methodology, technology and use of soil microbial biodiversity and its proper utilization for sustainable agriculture.

Theory

Unit I

Microbial evaluation and biodiversity, Microbial communities in ecosystems, New insights in below ground diverse of plant performance.

Unit II

Qualitative ecology of microorganisms; Biomass and activities.

Unit III

Nitrogen fixing organisms, Trends in diversity of N fixing organisms. Molecular approaches in characterizing N fixing microorganisms.

Unit IV

Serology and molecular characterization, ecological aspects of biodetermination, soil waste and water management

Unit V

Biodegradability, testing and monitoring of the bioremediation of xerobiotic pollutants and bacterial fertilizers.

Practicals

- Determination of soil microbes using classical techniques.
- Determination of soil microbial diversity using molecular techniques.
- Estimation of soil microbial biomass carbon, nitrogen and phosphorus.
- Estimation of key soil enzyme activities.
- Community level physiological profiling of microbial diversity.

Teaching methods/activities

Classroom teaching with AV aids, group discussion by students, field visit

Learning outcome

Experience on soil microbial diversity and planning for proper utilization.

Suggested Reading

- Lynch JM, Willey JM. *Soil Biotechnology*.
- Paul EA and Clark FE. *Soil Microbiology and Biochemistry*.
- Sherwood LM and Woolverton CJ. *Prescott's Microbiology*.
- Subba Rao NS. Advances In Agricultural Microbiology.
- Advances in Soil Microbiology: Recent Trends and Future Prospects Volume 1: Soil-Microbe Interaction Springer Link E Book
- Tapan Kumar Adhya, Banwari Lal, Balaram Mohapatra, Dhiraj. Paul, Subhasis Das, Advances In Soil Microbiology: Recent Trends And Future Prospect. Volume-1.
- Mandal S D and Bhatt Pankaj Bhatt. *Recent Advancements In Microbial Diversity 2020*

Teaching schedule

Theory

Unit	Lecture No.	Topic	Weightage %
I	1,2&3	Microbial evaluation and biodiversity,	08
	4,5,6&7	Microbial communities in ecosystems,	08
	8,9&10	New insights in below ground diverse of plant performance	06
II	11,12,13&14	Qualitative ecology of microorganisms;	10
	15&16	Biomass and activities.	10
III	17,18&19	Nitrogen fixing organisms,	04
	20,21,22&23	Trends in diversity of N fixing organisms.	08
	24&25	Molecular approaches in characterizing N fixing microorganisms.	08
IV	26&27	Serology and molecular characterization,	06
	28&29	Ecological aspects of biodetermination,	08
	30&31	Soil waste and water management	06
V	32&33	Biodegradability and its application	08
	34,35&36	Testing and Monitoring of the bioremediation of xerobiotic pollutants and bacterial fertilizers.	12
		Total	**100**

Practical's

Sr.No	Exercise No.	Name of Practical
1.	1&2	Preparation and collection material to determine soil microbes by using classical techniques.
	3	Determination of bacteria population by using classical techniques.
	4	Determination of fungi population by using classical techniques.
	5	Determination of actinomycetes population by using classical techniques.
2.	6&7	Determination of soil microbial diversity using molecular techniques.
	8	Determination of bacteria population by using molecular techniques.
	9	Determination of fungi population by using molecular techniques.
	10	Determination of actinomycetes population by using molecular techniques.
3.	11&12	Estimation of soil microbial biomass carbon.
	13&14	Estimation of soil microbial biomass nitrogen
	15&16	Estimation of soil microbial biomass phosphorus.
	17	Estimation of key soil enzyme activities.
4.	18	Community level physiological profiling of microbial diversity.

List of journals, e-journals				
Sr. No.	Jour ID	ISSAN	Name of Journals	NASS Score
1	A050	0065-2113	Advances in Agronomy	11.28
2	A118	0971-1570	Agropedology	#
3	A155	0973-4775	An Asian Journal of Soil Science	#*
4	A159	0003-2697	Analytical Biochemistry	8.88
5	A160	0003-2700	Analytical Chemistry	12.79
6	A281	0365-0340	Archives of Agronomy and Soil Science	8.14
7	A206	0972-1959	Annals of Plant and Soil Research	5.22
8	A297	1532-4982	Arid Land Research and Management (Arid Soil Research and Rehabilitation)	7.15
9	B092	0178-2762	Biology and Fertility of Soils	11.52
10	C012	0008-4220	Canadian Journal of Plant Science	6.85
11	C013	0703-8992	Canadian Journal of Remote Sensing	8.13
12	C014	0008-4271	Canadian Journal of Soil Science	7.17
13	C026	1758-3004	Carbon Management (Greenhouse Gas Measurement and Management)	7.67
14	C029	1523-0406	Cartography and Geographic Information Science	8.43
15	C032	0341-8162	Catena	10.33
16	C093	0009-8558	Clay Minerals	7.36
17	C094	0255-7193	Clay Research	**
18	C095	0009-8604	Clays and Clay Minerals	7.51
19	C098	2320-6411	Climate Change and Environmental Sustainability	5.28
20	C166	0970-4884	Crop Research - An International Journal	4.41
21	E010	0012-8252	Earth-Science Reviews	15.72
22	E142	1351-0754	European Journal of Soil Science (Journal of Soil Science)	9.74
23	I055	0971-2062	Indian Journal of Dryland Agricultural Research & Development	4.88
24	I089	2348-9677	Indian Journal of Plant and Soil	#*
25	I098	0970-3349	Indian Journal of Soil Conservation	5.28
26	I254	2251-824X	International Journal of Forest, Soil and Erosion	#
27	I255	0976-562X	International Journal of Forestry and Crop Improvement	#*
28	I319	2320-7035	International Journal of Plant & Soil Science	5.07
29	J441	1436-8730	Journal of Plant Nutrition and Soil Science (Zeitschrift for Pflanzenernahrung und Bodenkunde)	8.08
30	J490	0976-0806	Journal of Soil Salinity and Water Quality	4.94
31	J491	0718-9516	Journal of Soil Science and Plant Nutrition	8.16
32	J492	0022-4561	Journal of Soil and Water Conservation	8.21
33	J493	0022-457X	Journal of Soil and Water Conservation, India	5.20
34	J494	0971-2836	Journal of Soils and Crops	4.50

35	J495	1439-0108	Journal of Soils and Sediments	8.76
36	J571	0255-660X	Journal of the Indian Society of Remote Sensing	7.00
37	J572	0019-638X	Journal of the Indian Society of Soil Science	5.31
38	L014	0250-5371	Legume Research	6.53
39	L007	1085-3278	Land Degradation and Development	9.78
40	L008	0264-8377	Land Use Policy	9.68
41	P124	1214-1178	Plant Soil and Environment	7.32
42	P127	0032-079X	Plant and Soil	9.30
43	S053	0038-0717	Soil Biology and Biochemistry	11.80
44	S054	1838-675X	Soil Research (Australian Journal of Soil Research)	7.69
45	S055	0038-075X	Soil Science	7.12
46	S056	0361-5995	Soil Science Society of America Journal (Proceedings of Soil Science Society of America)	8.31
47	S057	0038-0768	Soil Science and Plant Nutrition	7.43
48	S058	0266-0032	Soil Use and Management	7.69
49	S059	2074-9546	Soil and Environment (Pakistan Journal of Soil Sciences)	#
50	S060	1532-0383	Soil and Sediment Contamination	7.25
51	S061	0167-1987	Soil and Tillage Research	10.60
52	W013	0049-6979	Water, Air and Soil Pollution	7.90
53	N074	1385-1314	Nutrient Cycling in Agroecosystems (Fertilizer Research)	8.45
54	P176	0973-6417	Progressive Research: An International Journal	3.78
55	T040	0970-2539	The Journal of Plant Science Research	4.10
Other Journals related to student/ faculty research work				

Restructured and Revised Syllabus

M.Sc. & Ph. D. (Agriculture)

in

Agricultural Physics

Submitted by

Broad Subject Coordinator
Associate Dean and Principal
College of Agriculture, VNMKV, Parbhani

Discipline Coordinator
Head, Department of
Soil Science and Agril. Chemistry
Dr. BSKKV, Dapoli

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Discipline: Agricultural Physics

Preamble

Agricultural Physics is the discipline dealing with the application of the principles and laws of physics in agriculture to study soil, plant and atmosphere for eco-friendly and sustainable exploitation of agricultural resources. Considering the recent advancement of knowledge and the need to make our students to be well aware of the recent developments in science the syllabi for the discipline of Agricultural Physics have been modified. The need for Agricultural Physics as a discipline in M.Sc. and Ph.D. program is emphasized due to the recent applications in crop modelling as a decision tool, satellite remote sensing based near real time crop condition monitoring, drone-based crop disease, pest surveillance, digital soil mapping, artificial intelligence based crop status characterization through image processing, Nano biosensors for quick and effective detection and management of crop requirement, etc. This could be possible in future, by starting the M.Sc. and Ph.D. programs in the discipline of Agricultural Physics in all the state agricultural universities of Maharashtra.

In the present syllabus emphasis on knowledge enrichment through field-based studies in the discipline of Agricultural Physics is made by introducing new courses on Satellite Meteorology, Nanotechnology, Image processing and development of sensors for soil, Crop and Environment Monitoring in agriculture. The modified syllabus also includes topics on Digital soil mapping, Farmers' participatory GIS, Nano-biosensors for monitoring crop irrigation, fertigation, etc. As per the New Education Policy 2020, the present syllabus will ensure the students of Agricultural Physics discipline to become holistic individuals with identified set of skills and values.

The modified syllabus with courses on Physics of Soil and Water Conservation, Fundamentals of Meteorology, General Climatology, Sensors for Soil, Crop and Environment Monitoring and Weather Hazards and its Management are related to the global developments to meet the triple challenges of feeding the growing global population, providing a livelihood for farmers, and protecting the environment. With the rise in the requirement for Biophysics, Remote sensing, nanotechnology, crop simulation modelling, biosensors, big data analytics artificial intelligence, etc. students of the discipline of Agricultural Physics will be a skilled work force as they will have the blend of multidisciplinary ability across the different disciplines of agricultural sciences.

Committee constituted as per the decision of 100thDICC Meeting for finalization of common syllabi in Agricultural Physics

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub Committees)	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Physical Science	Agricultural Physics	M.Sc. (Agri.)	Ph.D. (Agri.)	Dr. Syed Ismail Associate Dean, College of Agriculture, VNMKV, Parbhani	Dr.S. B. Dodake Head, Dept. of Soil Science and Agril. Chemistry Dr. BSKKV, Dapoli

Subcommittee constituted for finalization of Master's and Doctoral programmes syllabi in Agricultural Physics.

Sr.No.	Name and Designation	Remark
1	Dr. S.B. Dodake, Head, Dept. of Soil Science and Agril. Chemistry Dr. BSKKV, Dapoli	Discipline Coordinator
2	Dr. B. D. Bhakare, Head, Dept. Soil Science & Agril. Chemistry MPKV, Rahuri	Member
3	Dr. S. M. Bhoyar, Head, Dept. Soil Science & Agril. Chemistry, PDKV, Akola	Member
4	Dr. P. H. Vaidya, Head, Dept. Soil Science & Agril. Chemistry, VNMKV, Parbhani	Member
5	Dr. N. J.Ranshur, Professor, Dept. of Soil Science and Agril. Chemistry, COA, MPKV, Rahuri.	Member
6	Dr.S.L. Waikar, Associate Professor, Dept. of Soil Science and Agril. Chemistry, COA, VNMKV, Parbhani	Member
7	Dr.A. A. Aage, Assistant Professor, Dept. of Soil Science and Agril. Chemistry, COA Dr.PDKV, Akola	Member
8	Dr.R.V. Dhopavkar, Assistant Professor, Dept. of Soil Science and Agril. Chemistry, Dr.BSKKV, Dapoli	Member Secretory
	Invited members	
1.	Dr.V.A. Sthool, Head Department of Agril. Meteorology, College of Agril. Pune.	Invitee
2.	Dr.S.V. Bagade, Assistant Professor, Department of Agril. Meteorology, College of Agril. Pune.	Invitee
3.	Dr.A.V. Bulbule, Professor of Soil Science and Agril. Chemistry, College of Agril. Pune.	Invitee

Organization of Course Contents & Credit Requirements

Minimum Residential Requirement:

M.Sc.: 4 Semesters

Ph.D.: 6 Semesters

Name of the Department / Division

- Agricultural Physics

Nomenclature of Degree Programme

(a) M.Sc. Programme

M.Sc. Agriculture(Agricultural Physics)

(b) Ph. D. Programme

Ph.D. Agriculture(Agricultural Physics)

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

Eligibility for Admission

Master's Degree Programme

B.Sc.(Agri.) / B.Sc. (Hons.) Agriculture/ B.Sc. (Hort.)/ B.Sc. (Hons.) Horticulture/ B.Sc. (Forestry)/ B.Sc. (Hons.) Forestry under 10+2+ 4 system with minimum CGPA 5.50/10 or equivalent percentage of marks or equivalent degree with four years duration of agriculture related universities and having the Common Entrance Test in Agriculture conducted by competent authority.

Doctoral Degree Programme

Master's degree in the Department/Discipline of Agricultural Physicswith minimum CGPA 6.50/ 10 or equivalent percentage of marks and based on CET score conducted by MAUEB or AIEEA-ICAR. Agricultural universities which have expressed their willingness to utilize NTA score for their PG admissions. If required the scores will be provided by NTA.

Credit Requirements

Course Details	Master's Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

M.Sc. (Agri.)Agricultural Physics Course Structure

Course Code	Course Title	Credit Hours
AP 501*	Basic Concepts of Agricultural Physics-I	2+1
AP 502*	Basic Concepts of Agricultural Physics-II	3+0
AP 503	Fundamentals of Soil Physics	2+1
AP 504*	Mathematics in Agriculture	3+0
AP 505	Fundamentals of Meteorology	2+1
AP 506*	Principles of Biophysics	2+1
AP 507	Principles of Remote Sensing	2+1
AP 508	Physics of Soil and Water Conservation	2+1
AP 509	General Climatology	2+1
AP 510	Soil Physical Environment and Plant growth	2+1
AP 511	Simulation of Soil, Plant and Atmospheric Processes	2+1
AP 512	Principles of Physical techniques in agriculture	2+1
AP 513	Principles and Applications of GIS and GPS	2+1
AP 514	Nanoscience and Technology for Agriculture	2+0
AP 515	Remote Sensing in Agriculture	2+1
AP 591	Master's Seminar	1+0
AP 599	Master's Research	30

Semester wise core courses offered based on credit requirement M.Sc. (Agri.) Agricultural Physics

Course Code	Semester	Course Title	Credit Hrs.
AP 501*	I	Basic Concepts of Agricultural Physics- I	2+1
AP 502*	II	Basic Concepts of Agricultural Physics- II	3+0
AP 503	I	Fundamentals of Soil Physics	2+1
AP 504*	II	Mathematics in Agriculture	3+0
AP 505	I	Fundamentals of Meteorology	2+1
AP 506*	I	Principles of Biophysics	2+1
AP 507	I	Principles of Remote Sensing	2+1
AP 508	II	Physics of Soil and Water Conservation	2+1

AP 509	I	General Climatology	2+1
AP 510	II	Soil Physical Environment and Plant growth	2+1
AP 511	I	Simulation of Soil, Plant and Atmospheric Processes	2+1
AP 512	II	Principles of Physical techniques in agriculture	2+1
AP 513	I	Principles and Applications of GIS and GPS	2+1
AP 514	II	Nano science and Technology for Agriculture	2+0
AP 515	I	Remote Sensing in Agriculture	2+1
AP 591	III	Master's Seminar	1+0
		Total	33 +12
AP 599		Master's Research	0+30

***Compulsory Courses**

Compulsory Common PGS Courses: (Non-Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	0+1
PGS 502	I	Technical Writing and Communications Skills	0+1
PGS 503	II	Intellectual Property and its management in Agriculture	1+0
PGS 504	I	Basic Concepts in Laboratory Techniques	0+1
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

Optional /supporting courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Soil Science
2. Organic Farming
3. Horticulture
4. Agricultural Meteorology

5. Soil and Water conservation
6. Agronomy
7. Agricultural Statistics
8. Computer Application and Information Technology
9. Forestry

Some of the suggested courses are

Course Code	Semester	Course Title	Credit Hrs.
STAT 501	II	General Statistical Methods and Computer Applications	2+1
COM 501	II	Information Technology in Agriculture	2+1
STAT 511	I	Experimental Designs	2+1
FRM 503	I	Remote Sensing and Geographical Information System in Natural Resource Management	2+1
FRM 504	II	Land Use Planning and Watershed Management	2+1

Minor Disciplines:

1. Soil Science
2. Agril. Chemistry
3. Agronomy
4. Agril. Meteorology
5. Organic farming
6. Forestry

Minor Courses

Course Code	Semester	Course Title	Credit Hrs.
SOIL 502	II	Soil Fertility and Fertilizer use	2+1
SOIL 503	I	Soil Chemistry	2+1
AGRON 501	I	Morden Concepts in Crop Production	3+0
AGM 502	II	Fundamentals of Agril. Metrology	2+1

Department of Agricultural Physics

Course Plan of M.Sc. (Agri)

Major 20 + Minor 08+ Supporting 06 + NCCC 05 + Seminar 01+ Research 30 = 70/78

Course No	Title of Course	Credit	Remark
Semester I			
AP 501*	Basic Concepts of Agricultural Physics -I	2+1	Major
AP 506*	Principles of Biophysics	2+1	Major
AP 507	Principles of Remote Sensing	2+1	Major
SOIL 503	Soil Chemistry	2+1	Minor
AGRON 501	Modern Concepts in Crop Production	2+1	Minor
STAT 511	Experimental Designs	2+1	Supporting
PGS 501	Library and Information Services	0+1	NCCC
PGS 504	Basic Concepts in Laboratory Techniques	0+1	NCCC
	Total	**20**	
Semester II			
AP502*	Basic Concepts of Agricultural Physics -II	3+0	Major
AP 504*	Mathematics in Agriculture	3+0	Major
AP 505	Fundamentals of Meteorology	2+1	Major
Soil 502	Soil Fertility and Fertilizer use	2+1	Major
AGM 502	Fundamentals of Agril. Metrology	2+1	Minor
STAT 501	General Statistical Methods and Computer Applications	2+1	Supporting
COM 501	Information Technology in Agriculture	2+1	Supporting
PGS 502	Technical Writing and Communications Skills	0 +1	NCCC
PGS 503	Intellectual Property and its management in Agriculture	1+ 0	NCCC
	Total	**23**	
Semester III			
AP 511	Simulation of Soil, Plant and Atmospheric Processes	2+1	Major
Soil 591	Master's Seminar	1+0	Major
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0	NCCC
Soil 599	Research	0 +10	Research
	Total	**15**	
Semester IV			
Soil 599	Research	0 +20	Research
Total		**78**	
Major 24 +Minor 9 + Supporting 09 +NCCC 05+ Seminar 01 + Research 30 = Total 78			

Ph.D.(Agri) Agricultural Physics Course Structure

Course Code	Course Title	Credit Hours
AP 601*	Advanced Soil Physics	2+1
AP 602	Applied Soil Physics	2+1
AP 603	Crop Micrometeorology and Evapo-transpiration	2+1
AP 604*	Digital Image Processing	1+1
AP 605	Satellite Agrometeorology	2+1
AP 606	Sensors for Soil, Crop and Environment Monitoring	2+1
AP 607	Weather Hazards and its Management	2+0
AP 691	Doctoral Seminar I	1+0
AP 692	Doctoral Seminar II	1+0
AP 699	Doctoral Research	75

*the core courses compulsorily to be taken

Semester wise core courses offered based on credit requirement
Ph.D.(Agri.) in Agricultural Physics

Course Code	**Semester**	**Course Title**	**Credit Hrs.**
AP 601*	I	Advanced Soil Physics	2+1
AP 602	I	Applied Soil Physics	2+1
AP 603	II	Crop Micrometeorology and Evapotranspiration	1+0
AP 604*	II	Digital Image Processing	2+1
AP 605	I	Satellite Agrometeorology	1+1
AP 606	III	Sensors for Soil, Crop and Environment Monitoring	2+0
AP 607	I	Weather Hazards and its Management	1+1
AP 691	III	Doctoral Seminar I	1+0
AP 692	IV	Doctoral Seminar II	1+0
		Total	**13+5 =18**
AP 699		Doctoral Research	0+75

***Compulsory Courses**

Optional/supporting courses:

Supporting/optional courses of 600 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Soil Science
2. Organic Farming
3. Horticulture
4. Agricultural Meteorology
5. Soil and Water conservation
6. Agronomy
7. Agricultural Statistics
8. Computer Application and Information Technology
9. Forestry

Some of the suggested courses are

Course Code	Semester	Course Title	Credit Hrs.
STAT 602	I	Stimulation Techniques	1+1
STAT 604	I	Advanced Statistical Methods.	2+1
AGM 608	II	Computer Programmes and Software for Agril. Metrology Data Management	1+1

Minor Disciplines:

1. Soil Science
2. Agronomy
3. Agril. Meteorology
4. Soil and Water Conservation Engineering
5. Irrigation and Drainage Engineering

Minor Courses:

Course Code	Semester	Course Title	Credit Hrs.
SOIL 601	I	Recent Trends in Soil Physics	2+0
SOIL 603	I	Physical Chemistry of Soil	2+0
AGRON 601	I	Current Trends in Agronomy	3+0
AGRON 608	II	Research and Publication Ethics	2+0
AGM 601	I	Climate Change and Sustainable Development	2+1
AGM 608	II	Computer Programmes and Software for Agro meteorological Data Management	1+1

Department of Agricultural Physics
Course Plan of Ph,D. (Agri) for 2022-23

Major 12 + Minor 06+ Supporting 05 + Seminar 02+ Research 75 = 100/107

Course No	Title of Course	Credit	Remark
Semester I			
AP 601*	Advanced Soil Physics	2+1	Major
AP 602	Applied Soil Physics	2+1	Major
SOILS 601	Recent Trends in Soil Physics	2+0	Minor
SOILS 603	Physical Chemistry of Soil	2+0	Minor
AGRON 601	Current Trends in Agronomy	3+0	Minor
AGM 601	Computer Programmes and Software for Agro meteorological Data Management	1+1	Minor
STAT 602	Stimulation Techniques	1+1	Supporting
STAT 604	Advanced Statistical Methods	2+1	Supporting
	Total	**20**	
Semester II			
AP603	Crop Micrometeorology and Evapotranspiration	1+0	Major
AP 604*	Digital Image Processing	2+1	Major
AGRON 608	Research and Publication Ethics	2+0	Minor
AGM 608	Computer Programmes and Software for Agril. Metrology Data Management	1+1	Supporting
	Total	**08**	
Semester III			
AP 606	Sensors for Soil, Crop and Environment Monitoring	2+0	Major
AP 691	Doctoral Seminar I	1+0	Major
AP 699	Doctoral Research	0 +10	Research
	Total	**13**	
Semester IV			
AP 692	Doctoral Seminar II	1+ 0	Major
AP 699	Doctoral Research	0+25	Research
	Total	**26**	
Semester V			
AP 699	Doctoral Research	0+25	Research
Semester VI			
AP 699	Doctoral Research	0+15	Research
Total		**107**	
Major 12 + Minor 9 + Supporting 07 + Seminar 02 + Research 75 = Total 107			

Course Content

M.Sc. (Agri.) Agricultural Physics

Course title	**: Basic Concepts of Agricultural Physics -I**
Course code	**: AP 501**
Credit Hours	**: 2 + 1**

IV. Aim of the course :

To impart knowledge on the concepts of Agricultural Physics and physics laws. To understand stand growth, development and provide knowledge regarding the application of Agricultural Physics

V. Theory

Unit I

Relevance of Linear, circular, relative motions, conservation of mass, energy and momentum, forces in nature, range of their operation, action at a distance, gravitational field, potential, in agriculture.

Unit II

Concepts of Elasticity, stress-strain relations–moduli of elasticity, Hooke's law, molecular and structural basis of strengths of materials, hydrostatic pressure; surface tension, capillary rise, contact angle, hydro dynamics–laminar and streamline flow, Poiseuille's equation, Stoke's law and their application in agriculture.

Unit III

Principles of Thermometry, measurement of heat, specific heat, transfer of heat-conduction, convection and radiation, Change of phase, equation of state, vapour pressure and relative humidity, laws of thermodynamics, free energy, chemical potential along with their importance in agriculture.

Unit IV

Concepts of Kinetic theory of gases, Brownian motion, mean free path, simple harmonic motion, concepts of phase, phase difference, interference and reflection of sound waves, ultrasonic, alongwith their relevance in agriculture.

Unit V

Agricultural significance of Wave theory of light, Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; electromagnetic theory of light, geometrical optics, aberrations, resolving power, principles of optical instruments, illuminated and luminous objects and light sources; luminescence, incandescence, fluorescence, auto-fluorescence, phosphorescence, bioluminescence, qualitative and quantitative measurement of light, colour, optical spectrometry.

Unit VI

Principles of Electric charges, potential, field, intensity and strength of electric field, current, Coulomb's law, dielectrics, capacitance, electrostatic units, resistance, resistivity, Ohm's law, steady currents in conductors, insulators and semi-conductors, magnetic materials, induced magnetism, electro magnetism, measurement of magnetic field, geomagnetism, effects of the earth's magnetic field on life, electromagnetic inductions and applications in agriculture

VI. Practical

Use of the instruments in agriculture: Vernier/ Screw Gauge/ Spherometer, Sextant, Surface Tension, Viscosity, Interference Phenomenon, Optical Instruments (diffraction grating), Resistivity measurement (Potentiometer/ Wheatstone bridge),Young's Modulus.

VII. Suggested Readings

- RoseCW,AshhurstW,FlintHT.(Eds).1966*AgriculturalPhysics*.ISBN:9781483139258,p.248.
- Halliday D, Resnick R, WalkerJ. *Fundamentals of Physics.*
- Young HD, Freedman RA. *University Physics with Modern Physics.*
- Feynman RP, Leighton RB and Sands M. *The Feynman Lectures on Physics*
- Kittel C, Knight W and Ruderman MA. *Berkeley physics course: Mechanics* Vol.1.
- Purcell EM. *Berkeley physics course: Electricity and Magnetism*, Vol.II.
- Crawford FS, Jr. *Berkeley physics course: Waves.* Vol.III
- Krishna R.1960.*GeneralPropertiesofMatter*,Kitab Mahal, Allahabad.
- Mathur DS.1956.*Elementsof Properties of Matter*, S Chand & Co, New Delhi.
- Sengupta PC and Kohli BS.1967. *Text Book of Physics*, Vol I, II, Kitab Ghar, New Delhi.

Teaching Schedule

Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Relevance of Linear, circular, relative motions, conservation of mass, energy and momentum,	06
	3 - 4	Forces in nature range of their operation, action at a distance, gravitational field, potential, in agriculture.	06
II	5 - 7	Concepts of Elasticity, stress- strain relations– moduli of elasticity, Hooke's law, molecular and structural basis of strengths of materials,	08
	8 - 10	Hydrostatic pressure; surface tension, capillary rise, contact angle, hydro dynamics– laminar and stream line flow, Poiseuille's equation, Stoke's law and their application in agriculture.	09
III	11 - 13	Principles of Thermometry, measurement of heat, specific heat, transfer of heat- conduction, convection and radiation, in	08

		agriculture.	
	14 - 16	Change of phase, equation of state, vapour pressure and relative humidity, laws of thermo dynamics, free energy, chemical potential along with their importance	08
IV	17 - 19	Concepts of Kinetic theory of gases, Brownian motion, mean free path, simple harmonic motion,	07
	20 - 22	Concepts of phase, phase difference, interference and reflection of sound waves, ultrasonic, along with their relevance in agriculture.	07
V	23 - 25	Agricultural significance of Wave theory of light, Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; electromagnetic theory of light, geometrical optics, aberrations, resolving power,	10
	26 - 29	Principles of optical instruments, illuminated and luminous objects and light sources; luminescence, incandescence, fluorescence, auto-fluorescence, phosphorescence, bioluminescence, qualitative and quantitative measurement of light, colour, optical spectrometry.	11
VI	30 - 32	Principles of Electric charges, potential, field, intensity and strength of electric field, current, Coulomb's law, dielectrics, capacitance, electrostatic units, resistance, resistivity,	10
	33 - 36	Ohm's law, steady currents in conductors, insulators and semi-conductors magnetic materials, induced magnetism, electromagnetism, measurement of magnetic field, geomagnetism, effects of the earth's magnetic field on life, electro magnetic inductions and applications in agriculture	10
		Total	**100**

Practical Schedule

Exercise No	**Name of the Exercise**
1 - 3	Use of the instruments in agriculture: Vernier/ Screw Gauge
4- 8	Use of the instruments in agriculture: /Spherometer, Sextant, Surface Tension,
9 -11	Use of the instruments in agriculture: Viscosity, Interference Phenomenon,
12 - 15	Use of the instruments in agriculture: Optical Instruments (diffraction grating),
16 -18	Use of the instruments in agriculture: Resistivity measurement

	(Potentiometer/ Wheatstone bridge),Young's Modulus.

Course title : **Basic Concepts of Agricultural Physics-II**
Course code : **AP 502***
Credit Hours : **3+0**

Aim of the Course :

To impart knowledge on the concepts of Agricultural Physics and physics laws.

Theory

Unit I

Agricultural relevance of Maxwell's theory of electromagnetism, Atomic structure, Avogadro hypothesis and molecules, Atomic and molecular weights, atomic sizes, Quantum mechanics: uncertainty principle, De-Broglie hypothesis, Wave function, Eigenstate, Schrodinger equation.

Unit II

Principles of Spectroscopy: atomic and molecular spectra, Spectroscopy: atomic and molecular spectra, Cathode rays; positive rays ; Radioactivity; alpha-, beta-, and gamma-rays; Rutherford's theory of the scattering of alpha particles; X-rays, nature and properties; scattering of X-rays by atoms; Diffraction of X-rays and Bragg's law; characteristic X-ray spectra.

Unit III

Principles of Quantum theory in agriculture: Planck's quantum theory of thermal radiation; Quantum theory and Photo-electric effect; Elements of special theory of relativity, Atomic Nucleus and its constitution, Angular momentum of the nucleus; Nuclear transmutation of elements; proton- neutron hypothesis; Cosmic rays; elementary particles.

Unit IV

Radioactivity in agriculture: Natural radioactivity, types of radiations Interaction of radiation with matter and decay; Isotopes; isotopic masses and abundances; mass spectrograph; Stable isotopes; atomic masses, packing fractions & binding energy, Theory of radioactive disintegration; half-life and mean life; Mass spectrometers

Unit V

Application of radioactivity in agriculture: Nuclear fission, fusion, Nuclear reactions, neutron moderation, Nuclear energy, atomic power; Production of artificial isotope. Physical principles of Radiation detection; Types of radiation detectors; efficiency of detectors; Uses of radiation detectors, Elements of radioactive sources, handling, Radiation protection and cardinal principles of radiation safety.

Suggested Readings

- Chandrasekharan H and Gupta N. 2006. Fundamentals of Nuclear Science: Application in Agriculture, Northern Book Centre, New Delhi.
- David H, Robert R, Jearl W. Fundamentals of Physics
- Young HD, Freedman RA. University Physics with Modern Physics
- Feynman RP, Leighton RB and Sands M. The Feynman Lectures on Physics
- Wichmann EH. Berkeley physics course: Quantum physics. Vol IV
- Slater John C. 1960. Quantum Theory of Atomic Structure, Vol.1, McGraw Hill, New York.
- Burcham E. 1995. Nuclear Physics, ELBS/Longman.
- Kapoor SS and Ramamurthy VS. 1986. Nuclear Radiation Detectors, Wiley Eastern Ltd, New Delhi.
- Pochin E. 1983. Nuclear Radiation: Risks and Benefits, Clarendon Press, OXford.
- Rajam JB. 2000. Atomic Physics, S Chand and Co, New Delhi.
- Any Graduate level Text book of Physics, Lecture notes/hand-outs given in selected classes

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	**1 - 4**	Agricultural relevance of Maxwell's theory of electro magnetism, Atomic structure, Avogadro hypothesis and molecules,	**8**
	5 - 8	Atomic and molecular weights, atomic sizes, Quantum mechanics: uncertainty principle, De-Broglie hypothesis, Wave function, Eigenstate, Schrodinger equation.	**8**
II	**9 -13**	Principles of Spectroscopy: atomic and molecular spectra, Spectroscopy: atomic and molecular spectra, Cathode rays; positive rays; Radio activity alpha- ,beta-, and gamma-rays;	**9**
	14 - 18	Rutherford's theory of the scattering of alpha particles; X-rays, nature	**9**

		and properties; scattering of X-rays by atoms; Diffraction of X-rays and Bragg's law; characteristic X- ray spectra.	
III	**19 -24**	Principles of Quantum theory in agriculture: Planck's quantum theory of thermal radiation; Quantum theory and Photo-electric effect; Elements of special theory of relativity,	**12**
	25 -29	Atomic Nucleus and its constitution, Angular momentum of the nucleus; Nuclear transmutation of elements; proton-neutron hypothesis; Cosmic rays; elementary particles.	**10**
IV	**30 - 34**	Radioactivity in agriculture: Natural radioactivity, types of radiations Interaction of radiation with matter and decay;	**8**
	35 - 40	Isotopes; isotopic masses and abundances; mass spectrograph; Stable isotopes; atomic masses, packing fractions & binding energy, Theory of radioactive disintegration; half-life and mean life; Mass spectrometers	**12**
V	**41 - 46**	Application of radioactivity in agriculture: Nuclear fission, fusion, Nuclear reactions, neutron moderation, Nuclear energy, atomic power; Production of artificial isotope.	**12**
	47 - 50	Physical principles of Radiation detection; Types of radiation detectors; efficiency of detectors; Uses of radiation detectors, Elements of radioactive sources, handling, Radiation protection and cardinal principles of radiation safety	**12**
		Total	**100**

Course title **: Fundamentals of Soil Physics**
Course code **: AP 503**
Credit Hours **:2+1**

Aim of the Course :

To impart knowledge (both theoretical and practical) of the physical aspects of thesoilandexplainstheprocessesofretentionandtransportofwater,solute,heatandairinsoilandt heirroleforitspropermanagement.

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

Soil aeration and its characterization; measurement of soil aeration; Mechanisms of gaseous exchange, Ficks law gaseous diffusion; factors affecting.

Unit IX

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

Practical

- Particle-size analysis by hydrometer method and international pipette method
- Determination of particle density and bulk density of soils
- Soil water content determination
- Measurement of soil water potential by using tensiometer
- Soil-moisture characteristics
- Aggregate analysis by wet and dry sieving methods
- Measurement of Atterberg limits
- Measurement of soil strength
- Determination of saturated and unsaturated hydraulic conductivity
- Determination of infiltration rates

Suggested Reading:

- BaruahTC and Barthakur HP.2001.*Textbook of Soil Analysis*. Vikas Publishing House Pvt. Ltd, New Delhi
- Ghildyal BP and Tripathi RP.1987. *Soil Physics* .Wiley Eastern and New age International, New Delhi.
- Hillel D.1980 .*Applications of Soil Physics*. Academic Press, New York.
- Hillel D.1998. *Environmental Physics*, Academic Press, New York.
- Jury WA, Gardner W and Horton R. 2004. *Soil Physics*. John Wiley and Sons, New York.

- Klute A. (Ed). 2006. *Methods of Soil Analysis*. Part1. *Physical and Minerological Methods* (SSSA Book Series No.5), ASA and SSSA, Madison, Wisconsin.
- La lR and Shukla MK. 2004 .*Principles of Soil Physics*, Marcel Dekker, New York.
- Warrick AW .(Ed).2002. *Soil Physics Companion*, CRC Press, Boca Raton.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	**1 - 3**	Soil as a disperse three phase system; mass-volume relationships of soil constituents; sample problems.	**6**
II	**4 - 6**	Soil texture; nature and behaviour of soil particles; textural classes; particle-size analysis.	**8**
III	**7 - 9**	Soil structure- genesis, classification and evaluation; soil aggregation and dispersion;	**8**
	10	Soil conditioners; soil tilth. Puddling	**5**
IV	**11 - 13**	Consistency consistency limits; soil strength and its measurement; swelling and shrinkage; soil compaction; soil crusting; phenomenon and implications.	**10**
	14 -15	swelling and shrinkage; soil compaction; soil crusting; phenomenon and implications.	**6**
V	**16 - 18**	Soil water retention; soil moisture constants; energy concept of soil water; different components of soil water potential;	**10**
	19 -20	measurement of soil water content and potential; soil moisture characteristics; hysteresis.	**6**
VI	**21 -22**	Flow of water in soils; saturated and unsaturated flow; hydraulic conductivity of soils; soil-water diffusivity;	**6**
	23 -24	measurement of saturated and unsaturated hydraulic conductivity.	**5**
VII	**25 -27**	Infiltration, percolation, redistribution and evaporation of water; soil water balance; permeability; drainage.	**6**
VIII	**28**	Soil aeration and its characterization; measurement of soil aeration;	**6**
	29 - 31	Mechanisms of gaseous exchange, Ficks law gaseous diffusion; factors affecting.	**6**
IX	**32- 34**	Soil temperature and significance; thermal properties of soils; energy balance and mode of heat transfer in soils; factors affecting soil temperature;.	**6**
	35 -36	measurement of soil temperature; management of extreme soil temperatures	**6**

	Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1 - 2	Particle- size analysis by hydro meter method and international pipette method
3 - 4	Determination of particle density and bulk density of soils
5 -6	Soil water content determination
7	Measurement of soil water potential by using tensiometer
8 -9	Soil-moisture characteristics
10 - 11	Aggregate analysis by wet and dry sieving methods
12	Measurement of Atterberg limits
13	Measurement of soil strength
14 - 16	Determination of saturated and unsaturated hydraulic conductivity
17 - 18	Determination of infiltration rates

Course title : Mathematics in Agriculture
Course code : AP 504*
Credit Hours : 3+0

Aim of the Course :

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

Theory

Unit I

Vectors, matrices and determinants, inversion of matrices, Gauss Jordan method Eigen values and Eigen vectors, Orthogonality, Grahm-Schmidt processes, least square problems.

Unit II

Trigonometric functions and relations.

Unit III

Differentiation, Integration, Integration, applications, linear equations, Non-linear equations, Polynomials, Partial differential equations.

Unit IV

System of coordinates, Cartesian, cylindrical, spherical and polar coordinates, Three-dimensional geometry, Relative motion of frame of reference.

Unit V

Basic Probability theory Probability, probability distributions and applications, Curve fitting, Regression, Correlation, simple, multiple, partial Linear and non-linear.

Unit VI

Geo-statistics, Averaging and scaling methods, Fourier analysis, Numerical approximation, Numerical analysis, finite element method, Monte carlo analysis, Stochastic methods, Iterative and optimal techniques.

Suggested readings:

- Pal SK. Statistics for Geoscientist-Techniques and application
- Reddick HW. Advanced Mathematics for Engineers
- Ray M and Sharma HS. Mathematical statistics
- Wylie CR. Advanced Engineering Mathematics
- Higher Engineering Mathematics by Dr. B.S.Grewal

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 4	Vectors, matrices and determinants, inversion of matrices, Gauss Jordan method	8
	5- 10	Eigen values and Eigen vectors, Orthogonality, Grahm-Schmidt processes, least square problems.	10
II	11 --13	Trigonometric functions and relations	6
III	14 - 19	Differentiation, Integration, Integration, applications,	12
	20 --25	linear equations, Non-linear equations, Polynomials, Partial differential equations	10
IV	26 -29	System of coordinates, Cartesian, cylindrical, spherical and polar coordinates,	8
	30 -34	Three- dimensional geometry, Relative motion of frame of reference	8
V	35 -39	Basic Probability theory Probability, probability distributions and applications,	8
	40 -44	Curve fitting, Regression, Correlation, simple, multiple,	8

		partial Linear and non-linear.	
VI	**45 --49**	Geo-statistics, Averaging and scaling methods, Fourier analysis, Numerical approximation,	**10**
	50 -54	Numerical analysis, finite element method, Monte carlo analysis, Stochastic methods, Iterative and optimal techniques.	**12**
	Total		**100**

Course title : **Fundamentals of Meteorology**
Course code : **AP 505**
Credit Hours : **2+1**

Aim of the Course

To impart theoretical and practical knowledge about basic physical processes in the atmosphere which have direct and indirect relevance to agriculture.

Theory

Unit I

Atmosphere and its constituents, weather and climate; meteorology-meaning and scope; historical development; meteorological elements, instruments for measurement of meteorological elements; different branches of meteorology.

Unit II

Meteorological observatory and its classes; theory and working principles of surface meteorological instruments; automatic weather station; meteorological organizations–IMD, NCMRWF, IITM, WMO.

Unit III

Sun and earth; solar radiation and Laws of radiations-Plancks law, Stefan-Boltzman Law, Wiens displacement law, Kirchoffs law, solar constant; radiation receipt on earth surface; atmospheric and astronomical factors affecting solar radiation; ozone hole; albedo and net radiation sensible and latent heat, direct and diffuse radiation; radiation balance of the earth and atmosphere.

Unit IV

Thermal profile of the atmosphere; variation of pressure with height; hydrostatic equation and its application in atmosphere; geopotential, standard atmosphere, altimetry; concept of specific heat at constant volume and pressure; First and second law of thermodynamics, gas laws.

Unit V

Atmospheric moisture, vapour pressure, relative humidity, absolute humidity, specific humidity, mixing ratio, dew point temperature, vapour pressure deficit, psychromatric equations, T-phi diagram; lapse rates; Vertical stability of atmosphere, Virtual andpotentialtemperature,moistanddryadiabaticprocess;tropicalconvection.

Unit VI

Atmospheric motion; balancing forces- pressure gradient and Coriolis forces; isobar; pressure systems; geostrophic, cyclostrophic, thermal and gradient winds; trough, ridge and col; Divergence and vertical motion Rossby, Richardson,Reynolds and Froude numbers.

Unit VII

Cyclonic and anti cyclonic motions, tropical and extra-tropical cyclones and their structure, cyclone tracks over Indian regions; Air masses and fronts; Land and sea breeze; Mountain and valley winds.

Unit VIII

Clouds and their classification, theories of cloud formation, condensation nuclei, precipitation processes; artificial rain making, thunderstorms and dust storms; haze, mist, fog and dew, hail, hail suppression, fog and cloud – dissipation.

Unit IX

Weather charts and its reading, weather forecasting – now-cast, short, medium and long-range forecasting, numerical weather prediction; synoptic charts and synoptic approach to weather forecasting. Meteorological satellites for weather forecasts; forecast of Indian monsoon rainfall.

Practical

- Visit to meteorological observatory; meteorological instruments, Recording of weather parameters;
- Calculation of daily, weekly and monthly statistics;
- Exploration of meteorological websites– IMD, NCMRWF, IITM and WMO;
- Calculation of standard meteorological weeks and Julian days;
- Visual classification of clouds;
- Understanding synoptic weather charts;
- Climatic normal, climatic chart and identification of low and high pressure systems.

Suggested Reading

- Barry RG and Chorley RJ. 1982. *Atmosphere Weather and Climate*. ELBS (UK).
- Byers HR. 1959. *General Meteorology*. McGraw Hill (New York).
- Ghadekar SR. 2001. *Meteorology*. Agromet Publishers (Nagpur)

- Ghadekar SR. 2002. *Practical Meteorology*. Agromet Publishers (Nagpur).
- Menon PA. 1989. *Our Weather*. NBT (New Delhi).
- Petterssen S. 1958. *Introduction to Meteorology*. McGraw Hill (New York).
- Trewartha GT. 1954. *An Introduction to Climate*. McGraw Hill (New York).

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Atmosphere and its constituents, weather and climate; meteorology- meaning and scope;	5
	3 - 4	historical development; meteorological elements, instruments for measurement of meteorological elements; different branches of meteorology.	6
II	5 - 6	Meteorological observatory and its classes; theory and working principles of surface meteorological instruments;	5
	7 - 9	automatic weather station; meteorological organizations – IMD, NCMRWF, IITM, WMO.	7
III	10 - 12	Sun and earth; solar radiation and Laws of radiations- Plancks law, Stefan-Boltzman Law, Wiens displacement law, Kirchoffs law,	8
	13 - 15	Solar constant; radiation receipt on earth surface; atmospheric and astronomical factors affecting solar radiation; ozonehole; albedo and net radiation sensible and latent heat, direct and diffuse radiation; radiation balance of the earth and atmosphere	10
IV	16 - 17	Thermal profile of the atmosphere; variation of pressure with height; hydrostatic equation and its application in atmosphere;	5
	18 - 19	Geopotential, standard atmosphere, altimetry; concept of specific heat at constant volume and pressure; First and second law of thermodynamics, gas laws.	5
V	20 - 21	Atmospheric moisture, vapour pressure, relative humidity, absolute humidity, specific humidity, mixing ratio, dew point temperature, vapour pressure deficit,	5
	22 - 24	Psychromatric equations, T-phi diagram; lapse rates; Vertical stability of atmosphere, Virtual and potential temperature, moist and dry adiabatic process; tropical convection.	6
VI	25 - 26	Atmospheric motion; balancing forces- pressure gradient and	4

		Coriolis forces; isobar; pressure systems; geostrophic,	
	27 - 28	cyclostrophic, thermal and gradient winds; trough, ridge and col; Divergence and vertical motion Rossby, Richardson, Reynolds and Froude numbers.	**6**
VII	**29 -30**	Cyclonic and anticyclonic motions, tropical and extra-tropical cyclones and their structure, cyclone tracks over Indian regions; Air masses and fronts; Land and sea breeze; Mountain and valley winds.	**6**
VIII	**31**	Clouds and their classification, theories of cloud formation, condensation nuclei,	**4**
	32 -33	precipitation processes; artificial rain making, thunderstorms and dust storms; haze, mist, fog and dew, hail, hail suppression, fog and cloud – dissipation.	**7**
IX	**34**	Weather charts and its reading, weather forecasting – now-cast, short, medium and long-range forecasting,	**5**
	35 - 36	numerical weather prediction; synoptic charts and synoptic approach to weather forecasting. Meteorological satellites for weather forecasts; forecast of Indian monsoon rainfall.	**6**
		Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1 - 2	Visit to meteorological observatory; meteorological instruments, Recording of weather parameters;
3 - 4	Calculation of daily, weekly and monthly statistics;
5 - 9	Exploration of meteorological websites– IMD, NCMRWF, IITM and WMO;
10 - 12	Calculation of standard meteorological weeks and Julian days;
13	Visual classification of clouds;
14 -15	Understanding synoptic weather charts;
16 - 18	Climatic normal, climatic chart and identification of low and high pressure systems

Course title : Principles of Biophysics
Course code : AP 506*
Credit Hours : 2+1

Aim of the Course:

To impart theoretical and practical knowledge of interactive effects of various physical forces on life processes and their applications

Theory

Unit I

Introduction and scope of biophysics, Weak and strong interactions in biological systems, Structure and properties of water, Physical, chemical and biological origin of life

Unit II

Experimental techniques used for separation and characterization of bio-molecules: sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography amino acid and nucleotide sequence analysis.

Unit III

Spectroscopic techniques for bio-molecular characterization: UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction & its application in biology

Unit IV

Physics of photosynthesis, transpiration, chlorophyll fluorescence, principles of thermal and fluorescence imaging and its application in agriculture

Unit V

Principles of magnetic seed treatment and its application in agriculture, Transport phenomena in biological systems, active and passive transport; absorption and germination kinetics of seeds, tissue water status and its characterization by NMR, principles of NIR and its application in non-destructive characterization of grain quality

Unit VI

Fiber physics; strength, physical properties, micronaire, elastic properties, tensile strength, thermal resistance, water absorption, breaking, elongation, crystallinity

Unit VII

Bio-energetic- First and second laws of thermodynamics- Heat, work, entropy, enthalpy and free energy, Concept of negative entropy & its application in living systems; Information theory.

Practical

- Spectroscopy- Verification of Beer- Lambert's law;
- Spectroscopy-Absorption spectrum of chlorophyll a & b;
- Viscometer-Measurement of intrinsic viscosity and molecular mass;
- Polarimeter- Measurement of molar rotation;
- Measurement of leaf water potential;
- Measurement of Osmotic potential of seed;
- NMR spectroscopy-Relaxation time measurements, NMR Spectroscopy oil content measurement;
- Leaf Photosynthesis, Measurement of LAI.

Suggested Reading

- Cotterill RMJ. 2002. *Biophysics- An Introduction*, John Wiley & Sons, Ltd.
- Daniel M. 2005. Agrobios. *Basic Biophysics for Biologists.*
- Narayanan P. 2003. *Essentials of Biophysics* New Age International Publishers.
- van Holde KE, Johnson WC and P Shing Ho. 2006. *Principles of Physical Biochemistry.* Printice-Hall International, Inc.
- Wilson K and Walker J. *Practical Biochemistry-Principles and Techniques* Cambridge University Press.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Introduction and scope of biophysics, Weak and strong interactions in biological systems,	8
	3 - 5	Structure and properties of water, Physical, chemical and biological origin of life.	8
III	6 - 7	Experimental techniques used for separation and characterization of bio-molecules: sedimentation,	8
	8 - 10	ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography, amino acid and nucleotide sequence analysis.	10
III	11 - 12, 13 - 14	Spectroscopic techniques for bio-molecular characterization: UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction & its application in biology.	10
IV	15 - 16	Physics of photosynthesis, transpiration, chlorophyll	8

		fluorescence,	
	17 - 18	Principles of thermal and fluorescence imaging and its application in agriculture.	**6**
V	**19 - 21**	Principles of magnetic seed treatment and its application in agriculture, Transport phenomena in biological systems, active and passive transport;	**9**
	22 - 26	Absorption and germination kinetics of seeds, tissue water status and its characterization by NMR, principles of NIR and its application in non-destructive characterization of grain quality.	**12**
VI	**27 - 31**	Fiber physics; strength, physical properties, micronaire, elastic properties, tensile strength, thermal resistance, water absorption, breaking, elongation, crystallinity.	**10**
VII	**32 - 34**	Bio-energetic- First and second laws of thermodynamics- Heat, work, entropy, enthalpy and free energy,	**6**
	35 - 36	Concept of negative entropy &its application in living systems; Information theory.	**5**
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise
1 - 2	Spectroscopy- Verification of Beer-Lambert’s law;
3 - 5	Spectroscopy-Absorption spectrum of chlorophyll a & b;
6 - 8	Viscometer-Measurement of intrinsic viscosity and molecular mass;
9 - 10	Polarimeter- Measurement of molar rotation;
11	Measurement of leaf water potential;
12	Measurement of Osmotic potential of seed;
13 - 15	NMR spectroscopy-Relaxation time measurements, NMR Spectroscopy oil content measurement;
11- 18	Leaf Photosynthesis, Measurement of LAI.

Course title : Principles of Remote Sensing
Course code : AP 507
Credit Hours : 2+1

Aim of the Course:

To teach about basic principles and techniques of remote sensing and introduce its applications.

Theory

Unit I

Introduction, electromagnetic radiation, electromagnetic spectrum, physics of remote sensing, radiation interactions with the atmosphere and target, radiometric quantities, BRDF/BRF, remote sensing systems, characteristics of images

Unit II

Platforms, orbits, classification of sensors, satellite characteristics, pixel size, andscale, spectral, radiometric and temporal resolution

Unit III

Spectral signatures of natural targets in optical and thermal regions, physical basis of signatures, spectral indices.

Unit IV

Imaging and non imaging systems, multispectral imaging, hyperspectral imaging, thermal imaging, microwave and LIDAR, Fluorescence imaging, aerial remote sensing

Unit V

Weather, land, ocean and other observation satellites, Indian remote sensing satellites, data reception, data products

Unit VI

Thermal remote sensing: Principles, signature, measurements, IR detection and imaging echnology

Unit VI

Microwave remote sensing: principles, signatures, interferometry, radar basics, viewing geometry and spatial resolution, image distortion, target interaction, image properties.

Unit VII

Image analysis:Visual interpretation, digita image processing, pre-processing, enhancement, transformations, classification, accuracy, integration, processing of multispectral, hyperspectral, thermal and microwave images.

Unit VIII

Overview of remote sensing applications in earth resource management: agriculture, meteorology, forestry, landcover/ landuse, water resources

Practical

- Use of Spectroradio meter, Use of FTIR, Spectral signatures of different materials; Derivation and analysis of vegetation indices;
- Analysis of emissivity spectra;
- Familiarization with satellite imagery (FCC);
- Visual Image Interpretation;
- Satellite data acquisition and satellite Data Receiving Station;
- Digital Image processing– Introduction to software, GPS and Ground truth Collection;
- Digital image processing: Pre-processing, Enhancement and training site collection, classification and Post Classification Accuracy Assessment.

Suggested Reading

- Campbell JB.1996. *Introduction to Remote Sensing*, 2nd ed.,The Guilford Press, New York.
- Colwell RN.(Ed.) 1983. *Manual of Remote Sensing*, Vol.I, American Society of Photo grammetry, Falls Church,Va.
- Curran PJ.1985 *Principles of Remote Sensing*, Longman, London.
- David LVerbyla. 1995. *Satellite Remote Sensing of Natural Resources*, Lewis Pub.
- George Joseph.2005. *Fundamentals of Remote Sensing* ,2nd ed., University Press.
- Jansen JR.2004. *Introductory Digital Image Processing: A Remote Sensing Perspective*, 3rd ed., Prentice Hall.
- Lilisand TM, Kiefer RW and Chipman JW.2003. *Remote Sensing and Image Interpretation*, 5th ed., John Wiley & Sons, Inc.,New York.
- Panda BC. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.
- Sabins FF.1996. *Remote Sensing:Principles and Interpretations*, 3rd ed., W.H. Freeman.
- Patil V. D., R. M. Shinde and M. S. Deshmukh. 2012. Fundamentals of Remote Sensing and Applications (Abridged edition) Manik Publications, Latur, Maharashtra.

Teaching Schedule

Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Introduction, electromagnetic radiation, electromagnetic spectrum, physics of remote sensing,	8
	3 - 5	Radiation interactions with the atmosphere and target, radiometric quantities, BRDF/BRF, remote sensing systems, characteristics of images	10
II	6 - 8	Platforms, orbits, classification of sensors,	8

		satellite characteristics, pixel size, and scale, spectral, radio metric and temporal resolution	
III	**9 - 11**	Spectral signatures of natural targets in optical and thermal regions, physical basis of signatures, spectral indices.	**8**
IV	**12 - 14**	Imaging and non-imaging systems, multispectral imaging, hyperspectral imaging, thermal imaging,	**9**
	15 - 17	Microwave and LIDAR, Fluorescence imaging, aerial remote sensing	**9**
V	**18 - 20**	Weather, land, ocean and other observation satellites, Indian remote sensing satellites, data reception, data products	**8**
VI	**21- 23**	Microwave remote sensing: principles, signatures, interferometry, radar basics,	**8**
	24- 26	Viewing geometry and spatial resolution, image distortion, target interaction, image properties.	**8**
VII	**27- 30**	Image analysis: Visual interpretation, digital image processing, pre-processing, enhancement, transformations, classification, accuracy, integration, processing of multispectral, hyperspectral, thermal and micro wave images.	**12**
	31- 33	Classification, accuracy, integration, processing of multispectral, hyperspectral, thermal and micro wave images.	**8**
VIII	**34 - 36**	Overview of remote sensing applications in earth resource management: agriculture, meteorology, forestry, landcover/ landuse, water resources	**4**
		Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1- 4	Use of Spectro radiometer, Use of FTIR, Spectral signatures of different materials; Derivation and analysis of vegetation indices
5 - 6	Analysis of emissivity spectra
7 - 8	Familiarization with satellite imagery (FCC);
9-10	Visual Image Interpretation;
11 -13	Satellite data acquisition and satellite Data Receiving Station
14 -15	Digital Image processing – Introduction to software, GPS and Ground truth Collection;

16 - 18	Digital image processing: Pre-processing, Enhancement and training site collection, classification and Post Classification Accuracy Assessment

Course title : Physics of Soil and Water Conservation
Course code : AP 508
Credit Hours : 2+1

Aim of the Course :

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

Overview of soil and water conservation in India; soil and water conservation research; techniques for soil and water conservation for agricultural and non-agricultural land - use of mechanical structures and biological methods; wind erosion control.

Unit IX

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

Practical

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

Suggested Reading

- Fangmeier DD, Elliot WF, Wookman SR, Huffman RL and Schwab GO. 2006.*Soil and Water Conservation Engineering*. Delmer Learning.
- Flanagan DC.(Ed.). 1990. *WEPP* Second Edition, USDA-Water Erosion Prediction Project; Hill Slope Profile Model Documentation Corrections and Additions. NSERL Rpt. No. 4.National Soil Erosion Res. Services, USDA.
- Hudson N.1995. *Soil Conservation*. Iowa State University Press.
- Pierce FJ and Frge WW.1998. *Advances in Soil and Water Conservation*. CRC Press.
- Renald KG, Foster GR, Weesies GA, Cool DK and Yoder DC.2000. *Predictory Soil Erosion by Water*: *A Guide to Conservation Planning with the Revised Universal Soil Loss Equation(RUSLE)*.AgriculturalHandbookAH703.USDA.
- Singh G, Babu R and Chandra S. 1981. *Soil Loss Prediction Research in India*. Central Soil and Water Conservation Research and Training Institute, Dehradun. Bull. No. T12/D9.

Teaching Schedule
Theory

Unit.No.	Lecture No.	Topics to be covered	Weightage (%)
I	**1 - 3**	History of soil erosion; geological and accelerated erosion; agents of soil erosion; acceptable limits of soil erosion.	**8**
II	**4 - 6**	Soil erodibility; factors affecting soil erodibility - soil physical characteristics, land management,	**6**
	7 -8	Crop management; soil erodibility indices; empirical	**6**

		constants.	
III	**9 - 12**	Soil erodibility; factors affecting soil erodibility - soil physical characteristics, land management, crop management; soil erodibility indices; empirical constants.	**8**
IV	**13 - 15**	Rainfall erosivity; estimation of rainfall erosivity-EI_{30} index and kinetic energy, and their calculations; erosivity indices.	**8**
V	**16 - 19**	Run off measurements–current meters, flumes, weirs and orifice, stage level recorder, hydrographs; runoff estimation - quantities and rates of runoff, Rational formula, Cook's method.	**8**
	20 - 21	Runoff estimation - quantities and rates of runoff, Rational formula, Cook's method.	**8**
VI	**22 - 24**	Sediment measurement – multi plot divisor, Coshocton wheel sampler, point and depth integrated sediment samplers;	**6**
	25 - 26	Universal soil loss equation; estimation of soil loss and its prediction.	**6**
VII	**27- 29**	Physics of wind erosion-wind velocity, initiation and movement of soil particles; saltation, suspension and surface creep; soil physical properties affecting wind erosion.	**10**
VIII	**30 - 31**	OverviewofsoilandwaterconservationinIndia;soilandwaterconservationresearch;techniquesforsoilandwaterconservationforagriculturalandnon-agricultural land -	**8**
	32 - 33	Use of mechanical structures and biological methods; wind erosion control.	**6**
IX	**34 - 35**	Concept of watershed development and management - size and shape of watershed; characterization and management of watersheds using remote sensing and GIS;	**7**
	36	Under standing concept to integrated water shed management through case studies.	**5**
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise

1 - 9	Determination of soil erodibility indices-suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, rain drop erodibility index; computation of kinetic energy of falling rain drops
10 -11	Measurement of land slope using Abney's level
12 -13	Computation of rainfall erosivity index (EI_{30}) using rain gauge data
14 -15	Estimation of surface runoff/ water flow using different techniques
16 - 17	Estimation of soil losses
18	Visit to a watershed

Course title : **General Climatology**
Course code : **AP 509**
Credit Hours : **2+1**

Aim of the Course :

To learn about the climatic controls, climatic classifications, and their relevance in agriculture

Theory

Unit I

Sun and earth, solar system, solar constant; latitudes and longitudes of the earth, seasons, rotation and revolution, solstices and equinoxes, radiation receipt on earth surface, radiation balance of the earth and atmosphere.

Unit II

Earth's environment-atmosphere, hydrosphere, lithosphere and biosphere: Atmospheric constituents: Weather and climate- weather and climatic elements.

Unit III

Climatic controls, latitudinal and seasonal variation of insolation, temperature, pressure belts & wind system, precipitation.

Unit IV

Climatic classification: Koppen and Thornthwaite systems, Hargreaves,Troll, Trewartha and Papadakis systems. Climatic types-continental, maritime and monsoon climate; climatic indices, climatic zones.

Unit V

Climatology of India; monsoons- origin, branches onset, progress and withdrawal of south-west monsoon monsoon breaks, rainfall variability; El Nino, La Nina, QBO (quasi-biennial oscillation) and ENSO and their impacts on Indian economy. North-east monsoon. North-western disturbances and norwester shower.

Unit VI

Climate change and global warming, disastrous weather and climatic events indifferent regions and their frequencies. Heat & cold wave, frost, dust storm, lightning & thunder storm, cyclone, cloud burst, drought and flood - their impacts on public life and agriculture.

Unit VII

Drought climatology-Concept, definition, types of drought and their causes; rainfall and its variability, intensity, duration, beginning and end of drought and wet spells; moisture availability indices; Monitoring of drought; drought indices, crop water stress index, crop stress detection;

Practical

- Calculations of climatic normal;
- Determination of climate type of particular station using different climate classification systems;
- Rainfall probability analysis;
- Computation of drought indices;
- Indices for extreme weather events;
- Climatic water balance for climate classification

Suggested Reading

- Barry RG and Chorley RJ.1982. *Atmosphere Weather and Climate*. ELBS (UK)
- Critchfield HJ.1982. *General Climatology*. Prentice Hall of India (New Delhi).
- Das PK.1995. *The Monsoon*. NBT (New Delhi).
- Haurwitz B and Austin JM.1944. *Climatology*. McGraw-Hill.
- Lal DS. 2011.*Climatology* Sharda Pustak Bhavan, (Allahabad).

Journals

- *Journal of Climate*
- *International Journal of Climatology*
- *Climate and Development*
- *Climate Change*
- *Nature-Climate Change*

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 3	Sun and earth, solar system, solar constant; latitudes and longitudes of the earth, seasons, rotation and revolution, solstices and equinoxes,	9
	4 -5	Radiation receipt on earth surface, radiation balance of the earth and atmosphere.	6
II	6 - 8	Earth's environment-atmosphere hydrosphere, lithosphere and biosphere: Atmospheric constituents: Weather and climate-weather and climatic elements.	10
III	9 - 11	Climatic controls, latitudinal and seasonal variation of insolation, temperature, pressure belts & wind system, precipitation	6
IV	12 - 14	Climatic classification: Koppen and Thornthwaite systems, Hargreaves, Troll, Trewartha and Papadakis systems.	8
	15 - 16	Climatic types-continental, maritime and monsoon climate; climatic indices, climatic zones.	8
V	17 - 19	ClimatologyofIndia;monsoons-origin,branchesonset,progressandwithdrawalofsouth-westmonsoonmonsoonbreaks,rainfallvariability;	10
	20 - 22	ElNino,LaNina,QBO(quasi-biennialoscillation)andENSOandtheirimpactsonIndianeconomy.North-eastmonsoon.North-westerndisturbancesandnor'westershower.	12
VI	23 - 25	Climate change and global warming, disastrous weather and climatic events in different regions and their frequencies.	8
	26 - 28	Heat & coldwave, frost, duststorm, lightning & thunderstorm, cyclone, cloud burst, drought and flood - their impacts on public life and agriculture.	8
VII	29 - 33	Drought climatology- Concept, definition, types of drought and their causes; rainfall and its variability, intensity, duration, beginning and end of drought and wetspells;	10
	34 - 36	Moisture availability indices; Monitoring of drought; drought indices, crop water stress index, crop stress detection.	5
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise
1- 3	Calculations of climatic normal
4 - 7	Determination of climate type of particular station using different climate classification systems;
8 - 10	Rainfall probability analysis;
11 - 13	Computation of drought indices;
14 - 16	Indices for extreme weather events;
17 - 18	Climatic water balance for climate classification

Course title : Soil Physical Environment and Plant Growth
Course code : AP 510
Credit Hours : 2+1

Aim of the Course :

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

Theory

Unit I

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

Unit II

Soil water: Soil moisture– plant water relations, moisture regime available water, newer concepts of water availability, least limiting water range, soil-plant- atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration andevapotranspiration,dynamicsofwaterinthesoil-plant-atmospherecontinuum.

Unit III

Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.

Unit IV

Soil Temperature– effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching, radiation–heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere.

Unit V

Aeration– ODR critical oxygen concentration and factors affecting.

Unit VI

Field water balance–field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture

Unit VII

Nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, integrated nutrient management in relation to soil physical condition.

Unit VIII

Resource conservation technologies- bed planting & zero-tillage-types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term) on soil health.

Unit IX

Modelling : Interactions of soil, management and climatic factors on plant growth, development of sustainability indices.

VI. Practical

- Measurement of penetration resistance and LLWR, Plant water potential;
- Field saturated hydraulic conductivity, transpiration using Porometer;
- Root Length Density, Root Diameter, Root weight using Root Scanner, plant N content;
- Germination percentage as affected by temperature;
- Estimation of evapotranspiration losses, estimation of consumptive water use, production functions, field water balance components, water uptake by plants

Suggested Reading

- Doorenbos J and Pruitt WO.1975. *Crop Water Requirements*. FAO Irrigation and Drainage Paper 24. Rome.
- Hanks and Ascheroft.1980. *Applied Soil Physics*. Springer Verlag.

- Hillel D.1971. *Soil and Water: Physical Principles and Processes*. Academic Press.
- Hillel D.1998. *Environmental Soil Physics*. Academic Press.
- Slatyer RO.1967. P*lant- Water Relations*. Academic Press.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	**1 - 3**	Introduction: Effect of soil physical properties on plant growth - soil water, soil air, soil temperature, mechanical impedance and tillage practices.	**9**
II	**4 - 6**	Soil water: Soil moisture–plant water relations, moisture regime available water, newer concepts of water availability, least limiting water range,	**8**
	7 - 9	Soil-plant- atmosphere system as a physical continuum, plant uptake of soil moisture, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum.	**10**
III	**11 - 13**	Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots.	**10**
IV	**14 - 16**	Soil Temperature–effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching,	**8**
	17- 19	Radiation–heat budget and energy balance in the field, radiation use efficiency, radiation exchange in the field, exchange of heat and vapour to the atmosphere	**8**
V	**20 -21**	Aeration– DR critical oxygen concentration and factors affecting	**6**
VI	**22 - 24**	Field water balance– field water balance, irrigation and water use efficiency, consumptive use, plant uptake of soil moisture	**8**
VII	**25 - 27**	Nutrient uptake and use by plants, managing soil physical condition for improved nutrient use efficiency, integrated nutrient management in relation to soil physical condition	**8**

VIII	**28 - 31**	Resource conservation technologies- bed planting & zero-tillage-types, suitability and effect on soil physical properties, other resource conservation technologies and the impact (short and long term) on soil health.	**10**
	32 - 33	Other resource conservation technologies and the impact (short and long term) on soil health.	**8**
IX	**34 - 36**	Modelling: Interactions of soil, management and climatic factors on plant growth, development of sustainability indices	**7**
	Total		**100**

Practical Schedule

Sr. No.	Exercise No	Name of the Exercise
1	1 -4	Measurement of penetration resistance and LLWR, Plant water potential;
2	5 -7	Field saturated hydraulic conductivity, transpiration using Porometer;
3	8 -10	Root Length Density, Root Diameter, Root weight using Root Scanner, plant N content;
4	11 - 13	Germination percentage as affected by temperature;
5	14 -15	Estimation of evapo-transpiration losses,
6	16 -18	Estimation of consumptive water use, production functions, field water balance components, water uptake by plants

Course title : **Simulation of Soil, Plant and Atmospheric Processes**
Course code : **AP 511**
Credit Hours : **2+1**

Aim of the Course :
To impart the theoretical and practical knowledge of using simulation models for crop-environment interactions

Theory
Unit I

Fundamentals of dynamic simulation, systems, models and simulation.

Unit II

Descriptive and explanatory models, modelling techniques steps, states, rates and driving variables, feed backs and relational diagrams.

Unit III

Numerical integration, introduction to FST language.

Unit IV

Modelling crop environment and crop pest interactions, soil water, nitrogen and balance, introduction to a simple crop ecological model, applications of simulation modeling in environmental impact assessment and greenhouse gas emission.

Unit V

Data requirements and limitations of modelling; modeling crop- environment and pest interaction, soil, water, nitrogen and C balance; assessing crop growth, scheduling and management practices and water use planning through simulation tools.

Practical

- Scheduling planting and harvesting of crops;
- Drawing relational diagrams;
- Applying numerical integration techniques;
- Fitting probability distribution functions;
- Hands on model validation through statistical indices;
- FST programming language;
- Hands onto Info Crop model;
- Assessing crop growth through Info Crop model;
- Hands onto USAR model, Crop rotation & water use planning through USAR model.

Suggested Reading

- Cox GW, Atkins MD. 1979. *Agriculture Ecology*. Freeman & Co.
- Etherington JR. *Environmental and Plant Ecology*. John Wiley Sons.
- Mitchell R. *The analysis of Indian agro- ecosystem.*
- Odum OP. *Ecology*. Oxford & IBM Publishing Co.
- Sinclair TR and Gardener FP (Eds). *Principle of ecology in plant production*. CABI, UK.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 4	Fundamentals of dynamic simulation, systems, models and simulation.	12
II	5 - 7	Descriptive and explanatory models,	12
	8 - 11	Modeling techniques steps, states, rates and driving variables, feedbacks and relational diagrams.	14

III	**12 - 13**	Numerical integration, introduction to FST language.	**9**
IV	**14 -18**	Modelling crop environment and crop pest interactions, soil water, nitrogen and balance,	**12**
	19 - 24	Introduction to a simple crop ecological model, applications of simulation modeling in environmental impact assessment and greenhouse gas emission	**15**
V	**25 - 29**	Data requirements and limitations of modeling; modelling crop-environment and pest interaction, soil, water, nitrogen and C balance;	**15**
	30 - 36	Assessing crop growth, scheduling and management practices and water use planning through simulation tools.	**12**
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise
1-3	Scheduling planting and harvesting of crops;
4 -6	Drawing relational diagrams;
7	Applying numerical integration techniques;
8	Fitting probability distribution functions;
9 -10	Hands on model validation through statistical indices;
11	FST programming language;
12 -14	Hands on to Info Crop model;
15 -16	Assessing crop growth through Info Crop model;
17 - 18	Hands on to USAR model, Crop rotation & water use planning through USAR model

Course title : **Principles of Physical Techniques in Agriculture**
Course code : **AP 512**
Credit Hours : **2+1**

Aim of the Course

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

Theory

Unit I

Principles of measurements; laboratory, field and regional scales.

Unit II

Principles of optical and polarized microscopes; reflection, transmission and absorption in relation to properties of object; colorimetric techniques; single and double beam instruments; spectro photometry; Beer and Lambert law; fluorescence; Ramanspectra.

Unit III

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

Unit IV

Principles of infrared thermometry; thermal imaging, emissivity laws; characteristics of agricultural materials.

Unit V

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

Unit VI

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

Unit VII

Atomic absorption spectroscopy- principles, detection limits and sensitivity.

Unit VIII

Nuclear techniques - detection and measurements of charged particles, radiation monitoring instruments, radiation hazards evaluation and protection. Tracer methodology - isotopes and their applications in agriculture, gamma irradiation for genetic variability

Unit IX

Concepts of Nano Science and technology and their applications in agriculture

Unit X

NMR, NIR, mass spectrometer- principles and applications.

Practical

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

Suggested Reading

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

- Bhaskaran S, Ghosh SK and Sethi GR.1973. *Proceedings of the International Symposium on Use of Isotopes and Radiation in Agriculture and Animal Husbandry Research*, Nuclear Research Laboratory, IARI, New Delhi.
- Broetjes C.1965. *The Use of Induced Mutations in Plant Breeding*. Pergamon Press.
- Burcham E.1995.*Nuclear Physics*. ELBS/ Longman.
- Glasstone S. 1967.*Source Book of Atomic Energy*. Affiliated East West Press.
- Kapoor SS and Ramamurthy VS.1986. *Nuclear Radiation Detectors* .Wiley Eastern.
- Pochin E.1983. *Nuclear Radiation: Risks and Benefits*. Clarendon Press.
- Rajan JB.2000. *Atomic Physics*. S Chand & Co.
- Tiwari PN.1985. *Nuclear Techniques in Agriculture*. Wiley Eastern.
- Wolf G.1964. *Isotopes in Biology*. Academic Press.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Principles of measurements; laboratory, field and regional scales.	6
II	3 - 5	Principles of optical and polarized microscopes; reflection, transmission and absorption in relation to properties of object;	9
	6 - 8	Colorimetric techniques; single and double beam instruments; spectrophotometry; Beer and Lambert law; fluorescence; Ramanspectra.	8
III	9 - 12	Sensors and transducers; principles of leaf area meter, canopy analyser, quantum sensor, Spectro-radiometer, laser land leveler	8
	13 - 14	Photosynthetic system analyser for determination of plant water and photo synthetic parameters.	7
IV	15 - 17	Principles of infrared thermometry; thermal imaging, emissivity laws; characteristics of agricultural materials.	8
V	18 - 20	Principles of X-ray and its applications in clay mineralogy; small angle scattering.	8
VI	21 - 24	Principles and applications of electron microscopes; transmission and scanning electron microscopes; confocal microscope and its applications.	9
VII	25 - 26	Atomic absorption spectro scopy-principles, detection limits and sensitivity.	6
VIII	27 - 30	Nuclear techniques - detection and measurements of charged particles, radiation monitoring instruments, radiation hazards evaluation and protection.	9

		Tracer methodology - isotopes and their applications in agriculture, gamma irradiation for genetic variability	**8**
IX	**31 - 33**	Concepts of Nano Science and technology and their applications in agriculture	**6**
X	**34 - 36**	NMR, NIR, mass spectrometer- principles and applications	**8**
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise
1	Discharge of electricity through gases
2	Ionization current measurements
3 - 4	Photoelectric effect and measurements
5 - 6	Geiger Muller counter- quenching time
7 - 8	Thickness measurement of thin films/ foils/ papersheets
9	Half-life determination
10 - 11	Tracer applications of artificial radio nuclides
12	Multi-channel analyser
13	Neutron moisture meter
14 - 15	Use of NMR spectrometer
16	Seed irradiation with gamma rays
17 - 18	Radio carbon dating.

Course title : **Principles and Applications of GIS and GPS**
Course code : **AP 513**
Credit Hours : **2+1**

Aim of the Course :

To impart knowledge on dealing with spatial data and its applications in natural resource management

Theory

Unit I

Introduction; History of cartography and maps.

Unit II

Basic concepts and principles; GIS hardware and software requirements; common terminologies of geographic information system (GIS).

Unit III

Geographical data structures; relational data base management system; overview of MS Access.

Unit IV

Maps and projections: principles of cartography; Basic geodesy: Geoid/ Datum/ Ellipsoid; cartographic projections, coordinate systems, types and scales; accuracy of maps.

Unit V

GIS data collection, linking spatial and non-spatial data; Errors and quality control, data output.

Unit VI

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

Unit VII

Principles of graph theory, topology and geometry; spatial analysis: statistical analysis, measurement, proximity (buffering), overlay analysis, classification, network analysis, multi criteria analysis, site suitability analysis, nearest neighbor analysis.

Unit VIII

Surface modelling: Thiessen polygon, interpolation, DEM; Geostatistical analyses, spatial and non-spatial query.

Unit IX

Software and hardware requirements of GIS; Integrated image analysis and GIS; GIS for modelling.

Unit X

Web GIS/ Geoportal, 3D GIS, object-oriented GIS, mobile GIS, knowledge-based GIS; data ware housing, data mining; metadata, data interoperability, open GIS consortium, GIS customization, DSS and SDSS.

Unit XI

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

Unit XII

Basic Concepts, segments, working principles; Measuring distance and timing, errors in GPS data and correction; Differential GPS; Integration of GPS data with GIS data, use of GPS in remote sensing analysis; Past, present and future status of GPS; Applications of

GPS in agriculture and natural resource management.

Practical

- Overview of current GIS software: Arc Map/ Arc GIS/ QGIS;
- Introduction to MS Access;
- Data input (spatial data); digitization and scanning;
- Data input: editing, Data input: non-spatial attributes and linking with spatial data;
- Data base creation and map registration;
- Spatial analysis: Surface modelling, overlaying, buffering, neighborhood analysis, Coordinate data collection through GPS and its integration with GIS.

Suggested Reading

- Burroughs PA.1986. *Geographical information systems for land resources assessment*. Oxford University Press
- Chakraborty D and Sahoo RN. *Fundamentals of Geographic Information System*, Viva Books Pvt. Ltd, New Delhi.
- Longley PA, Goodchild MF, Maguire DJ and Rhind DW.1997. *Geographical Informatics Systems*. II Edition, New York, John Wiley. Online useful materials
- Laurini R and Thompson D.1992. *Fundamentals of Spatial Information Systems*. London, Academic Press, New York

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Introduction; History of cartography and maps	4
II	3 - 4	Basic concepts and principles; GIS hardware and software requirements; common terminologies of geographic information system (GIS).	6
III	5 - 6	Geographical data structures; relational database management system; overview of MS Access.	4
IV	7 - 9	Maps and projections: principles of cartography; Basic geodesy: Geoid/ Datum/Ellipsoid; cartographic projections, coordinate systems, types and scales; accuracy of maps	9
V	10 - 11	GIS data collection, linking spatial and non-spatial data; Errors and quality control, data output.	6
VI	12 - 13	Raster based GIS: spatial referencing, definition and representation, data structure, advantages and disadvantages;	6
	14 - 16	Vector based GIS: Definition, concept, data structure, capture and Vector and raster formats, vector to raster and	8

		raster to vector conversion, advantages and disadvantages	
VII	**17 - 18**	Principles of graph theory, topology and geometry; spatial analysis: statistical analysis, measurement,	6
	19 - 20	Proximity (buffering), overlay analysis, classification, network analysis, multi-criteria analysis, site suitability analysis, nearest neighbor analysis.	7
VIII	**21 - 22**	Surface modelling: Thiessen polygon, interpolation, DEM; Geostatistical analyses, spatial and non-spatial query.	5
IX	**23 - 24**	Software and hardware requirements of GIS; Integrated image analysis and GIS; GIS for modelling.	5
X	**25 - 26**	Web GIS/ Geoportal, 3D GIS, object-oriented GIS, mobile GIS,	6
	27 - 28	knowledge-based GIS; data ware housing, data mining; metadata, data interoperability, open GIS consortium, GIS customization, DSS and SDSS.	8
XI	**29 - 31**	Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).	8
XII	**32 - 34**	Basic Concepts, segments, working principles; Measuring distance and timing, errors in GPS data and correction; Differential GPS;	6
	35 -36	Integration of GPS data with GIS data, use of GPS in remote sensing analysis; Past, present and future status of GPS; Applications of GPS in agriculture and natural resource management.	8
		Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1 -3	Overview of current GIS software: Arc Map/ Arc GIS/ QGIS;
4	Introduction to MS Access;
5 -7	Data input (spatial data); digitization and scanning;
8 -11	Data input: editing, Data input: non-spatial attributes and linking with spatial data;
12 - 14	Data base creation and map registration;
15 -18	Spatial analysis: Surface modelling, overlaying, buffering, neighborhood analysis, Coordinate data collection through GPS and its integration with GIS.

Course title : **Nanoscience and Technology for Agriculture**
Course code : **AP 514**
Credit Hours : **2+0**

Aim of the Course :

To impart basic knowledge about nanoscience, properties of nanoparticles and their applications in biology.

Theory

Unit I

Outline of the course; Nano structure: growth of compound semiconductors, super lattices, self-assembled quantum dots, Nano-particles, nano tubes and Nanowires, fullerenes (buckballs, grapheme), Nano fabrication and nano-patterning; Optical, X-ray, and electron beam lithography, self- assembled organic layers, Process of synthesiso fnano powders, Electro-deposition, Important nano materials.

Unit II

Mechanical properties, Magnetic properties, Electrical properties, Electronic conduction with nano particles, Investigating and manipulating materials in the nano scale; Electron microscopy, scanning probe microscopy, optical microscopy for nano science and technology, X- ray diffraction, scanning tunneling microscopy, atomicforce microscopy.

Unit III

Nano-biology: Interaction between biomolecules and nano-particle surface, Different types of inorganic materials used for the synthesis of hybrid nano- bioassemblies. Applications of nano in agriculture, current status of nano biotechnology, Future perspectives of Nano biology, Nano sensors.

Unit IV

Types of nano material hazard their identification, toxicity and exposure assessment, threshold limit, characterization, health risk assessment.

Suggested readings:-

- Balndin AA and Wang KL.(Ed.) 2006. *Handbook of semiconductor nano structure and nano devices*. American Scientific Publishers, California.
- Challa Kumar (Ed.).2006. *Nanotechnologies for the lifesciences*. Willey-VCH GmbH, Weinheim.
- Gregory Timp.1999. *Nanotechnology*. Springer Verlag, New York.
- Margaret E Kosal.2009. *Nanotechnology for chemical and biological defence*. Springer, Dordrecht.
- Michael Kohler and Wolfgang Frintzsche.2007. *Nanotechnology: Introduction to nano structureing techniques*. Wiley- VCH Verlag GmbH, Weinheim.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 8	Outline of the course; Nano structure: growth of compound semiconductors, super lattices, self-assembled quantum dots, Nano-particles, nano tubes and Nanowires, fullerenes (buckballs, grapheme).	15
	9 -14	Nano fabrication and nano-patterning; Optical, X-ray, and electron beam lithography, self-assembled organic layers, Process of synthesis of nano powders, Electro-deposition, Important nano materials	15
II	15 - 18	Mechanical properties, Magnetic properties, Electrical properties, Electronic conduction with nanoparticles, Investigating and manipulating materials in the nanoscale;	15
	19 - 23	Electron microscopy, scanning probe microscopy, optical microscopy for nanoscience and technology, X-ray diffraction, scanning tunnel lingmicroscopy, atomic force microscopy.	13
III	24 -29	Nano-biology: Interaction between biomolecules and nano-particle surface, Different types of inorganic materials used for the synthesis of hybrid nano- bioassemblies.	15
	30 - 33	Applications of nano in agriculture, current status of nano biotechnology, Future perspectives of Nanobiology, Nanosensors.	15
IV	34 - 36	Types of nano material hazard their identification, toxicity and exposure assessment, threshold limit, characterization, health risk assessment.	12
	Total		**100**

Course title : **Remote Sensing in Agriculture**
(Pre-requisite AP 507 Principles of Remote Sensing)
Course code : **AP 515**
Credit Hours : **2+1**

Aim of the Course :
To impart knowledge about the remote Sensing techniques and their applications in agriculture.

Theory

Unit I

Scope of remote sensing in agriculture, sensors platforms and data availability for agricultural remote sensing and recent developments.

Unit II

Remote Sensing of soil spectroscopy of soils, differentiation and identification of soils, soil parameters by hyperspectral remote sensing, soil survey and resource mapping, soil health.

Unit III

Crop identification and discrimination, crop acreage estimation, monitoring of crop growth and phenology, yield modeling and forecasting.

Unit IV

Retrieval of crop biophysical parameters–empirical and radiative transfer approaches, assessing crop abiotic and biotic stresses, monitoring agricultural drought and early warning, crop loss assessment and insurance using remote sensing.

Unit V

Land use/ land cover mapping and change detection analysis, land use modelling, cropping system analysis land planning with reference to different agro eco-regions, land degradation process (Salinity, water logging, etc) and their evaluation by remote sensing.

Unit VI

Role of remote sensing in water resource development and management, identification of ground water potential zones, generation of different thematic maps for integrated watershed management; Microwave remote sensing for crop and soil studies, soil moisture mapping, flood assessment and management by remote sensing.

Unit VII

Precision farming principles-VRT, Modern techniques and machines. Remote sensing for plant phenotyping, post-harvest quality assessment.

Practical

- Use of Infrared thermometry and spectral data for crop stress monitoring;
- Hyper spectral data for soil and crop characterization;
- Computation of Spectral Indices for Soil and Vegetation;
- BRDFs and Radiative transfer modelling, processing of microwave remote sensing data;
- Salinity mapping from remote sensing data; Pre-processing of time series satellite data;
- Crop discrimination and acreage estimation;
- Crop yield modeling from satellite data;
- Land use and cover classification and change detection;
- Drought and crop condition monitoring, processing of image data for plant phenotyping.

Suggested Reading

- Barret EC and Curtis LF.1982. *Introduction to Environmental Remote Sensing*, Chapman & Hall, London.
- Colwell RN. (Ed.) 1983. *Manual of Remote Sensing*, Vol.II, American Society of Photogrammetry, Falls Church,Va.

- Jensen JR. 2006. *Remote Sensing of the Environment: An Earth Resource Perspective* ,2nd ed., Prentice Hall.
- Narayan LRA.1999. *Remote Sensing and its Applications*, Oscar Publ.
- Patel AN and Singh S.2004. *Remote Sensing: Principles and Applications*. Scientific Publ.
- Thenkabail P, Turral H, Biradar C and Lyon JG.(Eds) 2009. *Remote Sensing of Global Crop lands for Food Security*, CRC Press.
- Ustin S.2004. *Remote Sensing for Natural Resource Management and Environmental Monitoring*, 3rd ed., Wiley.

Teaching Schedule
Theory

Unit	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 3	Scope of remote sensing in agriculture, sensors platforms and data vailability for agricultural remote sensing and recent developments.	12
II	4 - 6	Remote Sensing of soil spectroscopy of soils, differentiation and identification of soils,	10
	7 - 9	Soil parameters by hyperspectral remote sensing, soil survey and resource mapping, soil health.	9
III	10 - 12	Crop identification and discrimination, crop acreage estimation, monitoring of crop growth and phenology, yield modeling and forecasting	12
IV	13 - 15	Retrieval of crop biophysical parameters–empirical and radiative transfer approaches, assessing crop abiotic and biotic stresses,	10
	16 - 17	Monitoring agricultural drought and early warning, crop loss assessment and insurance using remote sensing.	8
V	18 - 23	Land use/ land cover mapping and change detection analysis, land use modelling, cropping system analysis land planning with reference to different agro eco-regions, land degradation process (Salinity, water logging, etc) and their evaluation by remote sensing	15
VI	24 - 27	Role of remote sensing in water resource development and	10

		management, identification of ground water potential zones, generation of different thematic maps for integrated watershed management;	
	28 - 31	Microwave remote sensing for crop and soil studies, soil moisture mapping, flood assessment and management by remote sensing.	**8**
VII	**32 - 36**	Precision farming principles-VRT, Modern techniques and machines. Remote sensing for plant phenotyping, post-harvest quality assessment.	**6**
			100

Practical Schedule

Exercise No	Name of the Exercise
1 - 2	Use of Infrared thermometry and spectral data for crop stress monitoring;
3 - 4	Hyper spectral data for soil and crop characterization;
5 - 6	Computation of Spectral Indices for Soil and Vegetation;
7 - 8	BRDFs and Radiative transfer modelling, processing of microwave remote sensing data;
9 - 10	Salinity mapping from remote sensing data; Pre-processing of time series satellite data;
11	Crop discrimination and acreage estimation;
12 - 13	Crop yield modeling from satellite data;
14 - 15	Land use and cover classification and change detection;
16 - 18	Drought and crop condition monitoring, processing of image data for plant phenotyping.

Ph.D.Agri. (Agricultural Physics)

Course title : Advanced Soil Physics
Course code : AP 601
Credit Hours : 2+1

Aim of the Course:

To study the physical processes for transport of water, solute, heat and air in soil using advanced mathematical tools and techniques.

Theory

Unit I: Mathematical tools

Vector calculus: gradient, divergence and curlofa vector. Fourier series, Laplace and inverse Laplace transforms and their applications for solving flow and transport equations in soil analytically; Numerical approximations: finite difference methods for solving transport equations. Iterative procedures for solving linear and non linear equations, Monte Carlo simulation.

Unit II: Soil water transport

Saturated flow equations: Poiseuille's and Darcy's equations, Laplace equation of steady flow and Poisson equation for unsteady flow, three-dimensional saturated hydraulic conductivity and fluxes, Specific Storage Coefficient, Aquifer Transmissivity, conductance coefficient, Effective hydraulic conductivity for layered soils.
Unsaturated flow equations of Vadose zone: Buckinghum- Darcy equation, Richards equation; Unsaturated flow parameters: Unsaturated Hydraulic conductivity: Models for estimation– Gardener's model, vanGenucheten model, Brooks and Corey model and Kosugi model; Capillary Length Scales: Macroscopic and microscopic capillary lengths; Woodings equation for steady infiltration froma shallow pondedring. Preferential flow: Macropore Flow, fingering and Funnel flow; Measurement of saturated and unsaturated hydraulic conductivity**:** Lab methods- constant head and falling head methods,Field methods- infiltro meters and permea meters, instantaneous profile and field inverse methods; Numerical models of water flow –finite difference method. Infiltration models: Empirical models- Kostikov model, Horton model, Physical models - Green-Ampt and Philip models both for horizontal and vertical infiltration, Boltzmann transformation of wetting front for solving water flow during horizontal and vertical infiltration, computation of profile controlled and supply-controlled infiltration along with time of ponding, homogeneous and layered soil infiltration, curve number method, preferential flow. Solute transport: solute transport mechanisms: mass flow, diffusion, hydrodynamic dispersion, miscible and immiscible displacement, hypothetical and experimental break through curves, Convective-Diffusive equation (CDE), linear and non-linear adsorption, solution of CDE, analytical solution by Laplace transformation, numerical solutions by finite difference and finite element methods, applications, methods of determination of dispersion and diffusion coefficients.

Unit III: Soil heat flow

Equation of heat transport by conduction and its sine wave solution, damping depth and its significance. Measurement of soil thermal conductivity by single and dual probe and thermal diffusivity by time lag and amplitude-based methods. Computation of volumetric heat capacity by deVries method. Soil heat flux measurement by heat difference method. Flux plates. Estimation of thermal diffusivity by finite difference method.

Unit IV: Movement and exchange of gases in soils

Darcy's law for advective transport (non- isobaric system) of gases, deviation from Darcy's law, gas transport by diffusion in isobaric system (Fick's law). Multi component gas transport- Dusty Gas model, Stefan Maxwell equation. Gas permeability: laboratory and field measurement of gas permeability.

Practical

- Guelph Permea meter for field saturated hydraulic conductivity;
- Hydraulic conductivity by instantaneous profile method;
- Computation of dispersion and diffusion coefficients of CDE;
- Calibration of parameters of Green and Amptand Philip models and calculation of time of ponding, measuring thermal properties in field;
- Bruce and Klute method for computing hydraulic diffusivity under horizontal infiltration, Modelling water and heat transport in soil.

Suggested Reading

- Daniel Hillel. *Advanced Soil Physics*.
- Kirkham and Powers. *Advanced Soil physics*.
- Warrick AW. *Soil Physics Companion*.

Teaching Schedule
Theory

Unit	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 3	Vector calculus: gradient, divergence and curlofa vector. Fourier series, Laplace and inverse Laplace transforms and their applications for solving flow and transport equations in soil analytically;	5
	4 - 5	Numerical approximations: finite difference methods for solving transport equations. Iterative procedures for solving linear and nonlinear equations, Monte Carlo simulation.	5
II	6 - 8	Saturated flow equations: Poiseuille's and Darcy's equations, Laplace equation of steady flow and Poisson equation for unsteady flow,	5
	9 - 11	Three-dimensional saturated hydraulic conductivity and	7

		fluxes, Specific Storage Coefficient, Aquifer Transmissivity, conductance coefficient, Effective hydraulic conductivity for layered soils.	
III	12 - 14	Unsaturated flow equations of Vadose zone: Buckinghum-Darcy equation, Richards equation; Unsaturated flow parameters: Unsaturated Hydraulic conductivity:	**8**
	15 - 17	Models for estimation–Gardener's model, vanGenucheten model, Brooks and Corey model and Kosugi model; Capillary Length Scales: Macroscopic and microscopic capillary lengths;	**8**
	18 - 20	Woodings equation for steady infiltration from a shallow pondedring. Preferential flow: Macropore Flow, fingering and Funnel flow; Measurement of saturated and unsaturated hydraulic conductivity**:** Lab methods- constant head and falling head methods, Field methods-infiltrometers and permeameters, instantaneous profile and field inverse methods;	**8**
	21 - 23	Numerical models of water flow –finite difference method. Infiltration models: Empirical models-Kostikov model, Horton model, Physical models - Green-Ampt and Philip models both for horizontal and vertical infiltration,	**7**
	24 - 25	Boltzmann transformation of wetting front for solving water flow during horizontal and vertical infiltration, computation of profile controlled and supply- controlled infiltration along with time of ponding, homogeneous and layered soil infiltration, curve number method, preferential flow.	**8**
	26 - 27	Solute transport: solute transport mechanisms: mass flow, diffusion, hydro dynamic dispersion, miscible and immiscible displacement, hypothetical and experimental break through curves,	**6**
	28 - 30	Convective-Diffusive equation (CDE), linear and non-linear adsorption, solution of CDE, analytical solution by Laplace transformation, numerical solutions by finite difference and finite element methods, applications, methods of determination of dispersion and diffusion coefficients.	**9**
IV	30 - 31	Equation of heat transport by conduction and its sinewave solution, damping depth and its significance. Measurement of soil thermal conductivity by single and dual probe and thermal diffusivity by time lag and amplitude-based methods.	**7**
V	32 - 33	Computation of volumetric heat capacity by deVries method. Soil heat flux measurement by heat difference method. Flux plates. Estimation of thermal diffusivity by finite	**6**
VI	34 - 35	Darcy's law for advective transport (non-isobaric system) of gases, deviation from Darcy's law, gas transport by diffusion in isobaric system (Fick's law).	**6**
VII	35 - 36	Multi component gastransport- Dusty Gasmodel, Stefan	**5**

		Maxwell equation. Gas permeability: laboratory and field measurement of gas permeability.	
		Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1 - 3	Guelph Permeameter for field saturated hydraulic conductivity;
4 - 5	Hydraulic conductivity by instantaneous profile method;
6 - 7	Computation of dispersion and diffusion coefficients of CDE;
8 - 12	Calibration of parameters of Green and Ampt and Philip models and calculation of time of ponding, measuring thermal properties in field;
13 - 18	Bruce and Klute method for computing hydraulic diffusivity under horizontal infiltration, Modelling water and heat transport in soil.

Course title : **Applied Soil Physics**
(Pre-requisite AP 503 Fundamentals of Soil Physics
Course code : **AP 602**
Credit Hours : **2+1**

Aim of the Course:

To map soil properties for precision farming, assessment of soil quality, structural problems of different soils and their amelioration through appropriate conservation tillage, soil conditioning.

Theory

Unit I: Techniques for mapping soil properties and their use

Classical methods of interpolation: IDW, spline, global polynomial; Geostatistics: Spatial variability of soil properties: spatial dependence and spatial structure studies –empirical semi variogram and semi variogram models, kriging for interpolation – type of kriging, Geostistical analyst, 3D analyst and spatial analyst tools of GIS for mapping soil properties, Use of soil maps for soil health assessment and reducing input use in precision farming.

Unit II: Assessment of Soil quality

Definitions of soil quality, selection of minimum data set of physical, chemical and biological characteristics for quality assessment, indices of soil quality: Physical rating of soils, least limiting water range (LLWR) as an indicator of structural quality, Proctor compaction test, soil erodibility indices.

Unit III: Soil structural problems of major soil types and their amelioration

Management of highly permeable soils, slow permeable black soils, hardening of red chalka soils, shallow soils, soils with subsurface hardpan, tal lands, paddy soils, soil crusting

Unit IV: Soil tillage

Role of tillage for modification of soil structure, Assessment of site-specific tillage requirement based on soil and climatic properties, conservation tillage, effect of tillage on water and solute transport in soil. Nutrient availability, puddling, Effect of tillage on the nutrient availability.

Unit V:Soil conditioners

Water soluble conditioners types and soil hydrogels–mode and rate of their application and modification in soil water retention curve of different soil types. Influence of atmospheric demand on hydrothermal regimes of soils with conditioners.

Unit VI: Applications of remote sensing in surface soil moisture estimation:

Estimation of surface soil moisture by thermal and passive microwave techniques

Practical

- Empirical semivariogram and fitting appropriate semivariogram model;
- Preparation of prediction map of a soil property by kriging;
- Soil physical health assessment of a farm;
- Comparison of soil water retention curves of a soil with variable rates of applied conditioner;
- Computation of LLWR under different soil management practices.

Suggested Reading

- Daniel Hillel. *Advanced Soil Physics*.
- Gupta RP and Ghildyal BP. *Soil Structure*.
- Warrick AW. *Soil Physics Companion*.
- ARCGIS manual.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 5	Classical methods of interpolation: IDW, spline, global polynomial; Geostatistics: Spatial variability of soil properties: spatial dependence and spatial structure studies –empirical semi variogram and semi variogram models,	12
	6 - 10	Kriging for interpolation – type of Kriging, Geostistical analyst, 3D analyst and spatial analyst tools of GIS for mapping soil properties, Use of soil maps for soil health assessment and reducing input use in precision farming.	12
II	11 - 14	Definitions of soil quality, selection of minimum data set of physical, chemical and biological characteristics	10

		for quality assessment,	
	15 - 17	Indices of soil quality: Physical rating of soils, least limiting water range (LLWR) as an indicator of structural quality, Proctor compaction test, soil erodibility indices.	**10**
III	18 - 20	Management of highly permeable soils, slow permeable black soils, hardening of red chalka soils, shallow soils, soils with subsurface hardpan, tal lands, paddy soils, soil crusting	**12**
IV	21 - 23	Role of tillage for modification of soil structure, Assessment of site-specific tillage requirement based on soil and climatic properties,	**10**
	24 -27	Conservation tillage, effect of tillage on water and solute transport in soil. Nutrient availability, puddling, Effect of tillage on the nutrient availability.	**10**
V	28 - 31	Water soluble conditioners types and soil hydrogels–mode and rate of their application and modification in soil water retention curve of different soil types.	**9**
	32 - 33	Influence of atmospheric demand on hydrothermal regimes of soils with conditioners.	**7**
VI	34 - 36	Estimation of surface soil moisture by thermal and passive microwave techniques	**8**
		Total	**100**

Practical Schedule

Exercise No	Name of the Exercise
1- 5	Empirical semivariogram and fitting appropriate semivariogram model;
6 -9	Preparation of prediction map of a soil property by Kriging;
10 - 12	Soil physical health assessment of a farm;
13 - 15	Comparison of soil water retention curves of a soil with variable rates of applied conditioner;
16 - 18	Computation of LLWR under different soil management practices.

Course title : **Crop Micrometeorology and Evapotranspiration (Pre-requisite AP 505 Fundamentals of Meteorology)**
Course code : **AP 603**
Credit Hours : **2+1**

Aim of the Course :

To impart advanced theoretical and practical knowledge about the physical processes in the atmosphere near the ground for growing crop plants with special emphasis of evapotranspiration process

Theory

Unit I

Micro-meso-and macro-climates and their importance, Atmosphere near the ground–bare soil and crop surfaces, exchange of mass, momentum and energy between surface and overlaying atmosphere, exchange coefficients, Richardson number & Reynold's analogy, Mixing length theory, boundary layer equations, surface layer, Ekman layer, frictional affects, eddy diffusion, forced & free convection. Wind profile near the ground; roughness and zero plane displacement.

Unit II

Micro meteorology of plant canopies: Radiation, temperature, wind, humidity and carbon dioxide profiles in crops; Influence of topography on micro climate; variation in microclimate under irrigated and rainfed conditions; Micro meteorology of field crops rice and wheat, forest and orchards etc.

Unit III

Hydrological cycle and concept of water balance, concepts of evaporation. Evapotranspiration, potential, reference and actual evapotranspiration, consumptive use, different approaches of ET determination by empirical methods, energy balance and Bowen's ratio methods, water balance single and multi-layered soil methods, aerodynamic, Eddy correlation and combination approaches, field lysimetric approaches and canopy temperature-based methods; Advantages and limitations of different methods.

Unit IV

Measurement of water use efficiency/ water productivity, irrigation scheduling and yield functions; Advective energy determination and its effect on water use by crops; Physiological variation in relation to crop growth and development.

Practical

- Micro metsensors and automatic weather station;
- Global and net radiation diurnal variations;
- Temperature profile, Humidity profile and Wind profile in the crops at different stages;
- Energy balance components for Regional Research station
- PET by Thornthwaite's method, Blaney Criddle method, Radiation (Makkink's) method;
- Bowen's Ratio, Aerodynamic method, Combination (FAO-56) method, Pan Evaporation, Lysimeter, Eddy Covariance.

Suggested Reading

- *Disaster Management in India* ,Ministry of Home Affairs, Govt. of India, 2011.
- *Manual of Drought Management*, Ministry of Agriculture, Govt. of India, 2016.
- *Textbook of Disaster Management*, by Nitesh Kumar, Satish Serial Publishing House.

Journals

- *Natural Hazards*
- *Disasters*
- *Agriculture & Forest Meteorology*

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1- 5	Micro-, meso- and macro-climates and their importance, Atmosphere near the ground–bare soil and crop surfaces, exchange of mass, momentum and energy between surface and overlaying atmosphere, exchange coefficients,	12
	6 -10	Richardson number & Reynold's analogy, Mixing length theory, boundary layer equations, surface layer, Ekm anlayer, frictional affects, Eddy diffusion, forced & free convection.	15
II	11 - 12	Wind profile near the ground; roughness and zero plane displacement.	8
III	13 - 16	Micro meteorology of plant canopies: Radiation, temperature, wind, humidity and carbon dioxide profiles in crops;	10
	17 - 20	Influence of topography on microclimate; variation in	12

		microclimate under irrigated and rainfed conditions; Micrometeorology of field crops rice and wheat, forest and orchards etc.	
IV	**21 - 25**	Hydrological cycle and concept of water balance, concepts of evaporation. evapotranspiration, potential, reference and actual evapotranspiration, consumptive use, different approaches of ET determination by empirical methods, energy balance. and Bowen's ratio methods	**15**
V	**26 -30**	Water balance single and multi-layered soil methods, aerodynamic, Eddy correlation and combination approaches, fieldlysimetric approaches and canopy temperature- based methods; Advantages and limitations of different methods.	**15**
VI	**31 - 33**	Measurement of water use efficiency/ water productivity, irrigation scheduling and yield functions;	**5**
	34 -36	Advective energy determination and its effect on water use by crops; Physiological variation in relation to crop growth and development.	**8**
	Total		**100**

Practical Schedule

Exercise No	**Name of the Exercise**
1 - 2	Micromet sensors and automatic weather station;
3 - 4	Global and net radiation diurnal variations;
5- 8	Temperature profile, Humidity profile and Wind profile in the crops at different stages;
9	Energy balance components for Regional Research station
10 - 13	PET by Thornthwaite's method, Blaney Criddle method, Radiation (Makkink's) method;
14 -18	Bowen's Ratio, Aerodynamic method, Combination (FAO-56) method, Pan Evaporation, Lysimeter, Eddy Covariance.

Course title	**: Digital Image Processing**
	(Pre-requisite: AP 507 Principles of Remote Sensing)
Course code	**: AP 604**
Credit Hours	**: 1+1**

Aim of the Course:

To impart advanced technical and practical knowledge about the image processing procedures with emphasis on their applications in agriculture

Theory

Unit I

Introduction- Image processing display systems. Initial statistical extraction- Univariate and multivariate image statistics, histogram and its significance in remote sensing data. Pre-processing - Introduction, missing scan lies, desk tripping methods, geometric correction and registration, atmospheric corrections, illumination and view angle effects.

Unit II

Imager eduction, image magnification, contrast enhancement; linear, non-linear, ratioing, edge enhancement; linear, non-linear; low pass filters, high pass filters, edge detection, point and neighborhoods operation Image transform- Arithmetic operations'-base dimage transforms, principle component analysis, discriminate analysis. Fouriertrans forms, Fast Fourier frequency domain filters and vegetation indices.

Unit III

Image compression fundamentals: Coding, inter pixel and Psyco-visual redundancy, and fidelity criteria. Image compression models: Source encoder and decoder, channel encoder décor, Elements of information theory: Measuring information, entropy, the information channel fundamental coding theorems and using information theory, Image Fusion.

Unit IV

Image segmentation: Detection of points, lines and edge detection and combined detection Edge linking and boundary detection: Local processing, Global processes via Hough transform; Thresholding: foundation, role of illumination, simple global thresholding, optimal thresholding. Split and merge and texture based segmentation.

Unit V

Classification: Geometrical basis, unsupervised & supervised techniques; Advance classification techniques: Use of external data, contextual information, feature - sub-feature study, classification accuracy; Change detection - the nature of change detection, change detection algorithms, image differencing, and image rationing and classification comparisons; Imaging Spectroscopy, Data Processing techniques, data mining techniques, Spectral angle mapping, Spectral unmixing, Construction digital terrain models, Application of DTMs – contour generation, fill, fly though; slope and aspect; viewshed analysis; watershed and drainage extraction; volumetric analysis; preparation of orthoimages

Practical

- Digital Image processing–Introduction to software, MATLA Band R software, Image acquisition;
- Digital image processing: Pre-processing, Enhancement and training site collection, classification;
- Post Classification, Accuracy Assessment;
- Processing of microwave image;
- Processing of thermal image;
- Processing of Hyper spectral image: Pre-processing and classification, Multi-resolution image Fusion.

Suggested Reading

- Gonzalez RC and Woods RE.2014. *Digital Image Processing*. Pearson.
- Jensen JR. 1986. *Introductory Digital Image Processing: A Remote Sensing Perspective*. Prentice Hall.
- Qihao Weng 2011. *Advances in Environmental Remote Sensing: Sensors, Algorithms and Applications*, CRC Press.

Journal

- *IEEE Trans. Geoscience and Remote Sensing*
- *IEEE Transactions on Image Processing*
- *International Journal of Image Processing- IJIP- CSC Journals*
- *Signal Processing: Image Communication- Journal- Elsevier*

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 2	Introduction- Image processing display systems. Initial statistical extraction-univariate and multivariate image statistics, histogram and its significance in remote sensing data. Pre-processing - Introduction, missing scan lies, desk tripping methods,	10
II	3	Geometric correction and registration, atmospheric corrections, illumination and view angle effects.	7
III	4 - 5	Imager education, image magnification, contrast enhancement; linear,non-linear, ratioing, edge enhancement; linear,non-linear; low pass filters, high pass filters, edge detection, point and neighbourhood	10
	6	Operation Image transform- Arithmetic operations'-based image transforms, principle component analysis, discriminate analysis.	8

IV	**7**	Fourier transforms, Fast Fourier frequency domain filters and vegetation indices.	**6**
V	**8 - 9**	Image compression fundamentals: Coding, interpixel and Psyco-visual redundancy, and fidelity criteria. Image compression models: Source encoder and decoder, channel encoder décor,	**10**
	10 - 11	Elements of information theory: Measuring information, entropy, the information channel fundamental coding theorems and using information theory, Image Fusion.	**9**
VI	**12 - 13**	Image segmentation: Detection of points, lines and edge detection and combined detection Edge linking and boundary detection: Local processing, Global processes via Hough transform;	**8**
	14	Thresholding: foundation, role of illumination, simple global thresholding, optimal thresholding. Split and merge and texture based segmentation	**6**
VII	**15 - 16**	Classification: Geometrical basis, unsupervised & supervised techniques; Advance classification techniques: Use of external data, contextual information, feature - sub-feature study, classification accuracy; Change detection - the nature of change detection, change detection algorithms, image differencing, and image rationing.	**10**
VIII	**16 - 17**	classification comparisons; Imaging Spectroscopy, Data Processing techniques, data mining techniques, Spectral angle mapping, Spectral unmixing, Construction digital terrain models, Application of DTMs – contour generation, fill, fly though; slope and aspect; viewshed analysis; watershed and drainage extraction; volumetric analysis; preparation of orthoimages.	**10**
	18	Application of DTMs – contour generation, fill, fly though; slope and aspect; viewshed analysis; watershed and drainage extraction; volumetric analysis; preparation of orthoimages.	**6**
	Total		**100**

Practical Schedule

Exercise No	Name of the Exercise
1 - 4	Digital Image processing–Introduction to software, MAT LAB and R software, Image acquisition;

5 - 9	Digital image processing: Pre-processing, Enhancement and training site collection, classification;
10 - 11	Post Classification, Accuracy Assessment;
12	Processing of microwave image;
13	Processing of thermal image;
14 -18	Processing of Hyperspectral image: Pre-processing and classification, Multi-resolution image Fusion.

Course title **: Satellite Agrometeorology**
(Pre-requisite: AP 505 Fundamental of Meteorology)
Course code **: AP 605**
Credit Hours **: 2+1**

Aims of the Course :

To learn the use of satellite images for retrieval agro-meteorological parameters and their applications in agriculture.

Theory

Unit I

Scope and importance of agro meteorology from space, types of meteorological satellites–Geo stationary and Polar orbiting.

Unit II

International satellite systems and their payloads – NOAA, S-NPP, TERRA and AQUA, DMSP, METEOSAT, GOES, TRMM, etc., National satellite systems and their payloads– INSAT, IRS/ RESOURCESAT, MEGHA-TROPIQUES, RISAT, OCEANSAT, etc., Agromet parameter's requirements and satellite data products available.

Unit III

Retrieval of cloud type and structure in visible and infrared regions, estimation of rainfall by visible, infrared and passive and active microwave techniques.

Unit IV

Retrieval of land surface emissivity and temperature – single channel and split window algorithms, components of surface radiation balance – global radiation, surface albedo and out going long wave radiation, estimation of latent heat flux (ET), sensible heat and roughness parameter.

Unit V

Retrieval of surface soil moisture by thermal and passive microwave, retrieval of crop biophysical parameters by empirical and physical techniques.

Unit VI

Vegetation phenology and dynamics, crop yield modelling, linking Simulation models and remote sensing, crop growth monitoring system

Unit VII

Drought monitoring, assessment and management, modeling netprimary productivity of agroecosystems, agroecological zoning using remote sensing and GIS, remote sensing of air pollutants and green house gases.

Practical

- Handling MODIS image products (Reflectance, LAI, fAPAR, LST);
- Handling SPOT VGT Products, PROSAIL MODEL, Retrieval of: LST, Albedo, Radiation,
- Estimation of Crop Phenology from multi-temporal satellite images,
- Spectral yield model, Remote sensing- based Drought indices and Drought assessment and Spatial Net Primary Productivity modelling.

Suggested Reading

- Lecture Notes Module II: *RS & GIS Applications in Agriculture & Soil Science*, CCSTEAP, Indian Institute of Remote Sensing, Dehradun, India
- Lecture Notes on *Satellite Meteorology & Global Change*, Vol 1, 2 & 3, CSSTEAP, Space Applications Centre, ISRO, Ahmedabad, India
- Molly E. Brown.2008. *Famine Early Warning Systems and Remote Sensing Data*, Springer.
- Okamoto K. (Ed.).2001. *Global Environment Remote Sensing*, IOS Press.
- Shivkumar MVK, Roy PS, Harmsen K and Saha SK.2004. *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, WMO, Geneva.
- Special Issue on Remote Sensing Applications in Meteorology, *Mausam*, Vol 54, No. 1,Jan 2003. Toselli F.(Ed.). 1989. *Applications of Remote Sensing to Agrometeorology*, Kluwer Academic Publishers, London.
- Ustin S.2004. *Remote Sensing for Natural Resource Management and Environmental Monitoring*, 3rd ed., Wiley.
- Vaughan RA. 1987. *Remote Sensing Applications in Meteorology and Climatology*, NATO Science Series C.

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	**1- 4**	Scope and importance of agrometeorology from space, types of meteorological satellites– Geostationary and Polar orbiting	**10**
III	**5 - 9**	International satellite systems and their payloads – NOAA, S-NPP, TERRA and AQUA, DMSP, METEOSAT, GOES, TRMM, etc.,	**12**
	10 - 14	National satellite systems and their payloads–INSAT, IRS/ RESOURCESAT, MEGHA-TROPIQUES, RISAT, OCEANSAT, etc.,	**12**
	15 -16	Agromet parameter's requirements and satellite data products available.	**8**
III	**17 -18**	Retrieval of cloud type and structure in visible and infrared regions, estimation of rainfall by visible, infrared and passive and active microwave techniques.	**10**
IV	**19 -20**	Retrieval of land surface emissivity and temperature – single channel and splitwindow algorithms,	**6**
	21 -23	components of surface radiation balance – global radiation, surface albedo and outgoing longwave radiation, estimation of latent heat flux (ET), sensible heat and roughness parameter.	**10**
V	**24 - 26**	Retrieval of surface soil moisture by thermal and passive microwave, retrieval of crop biophysical parameters by empirical and physical techniques.	**8**
VI	27 - 30	Vegetation phenology and dynamics, crop yield modelling, linking Simulation models and remote sensing, crop growth monitoring system	10
VII	**31 - 33**	Drought monitoring, assessment and management, modeling netprimary productivity of agro ecosystems,.	**8**
	34 -36	Agro ecological zoning using remote sensing and GIS,	**6**

		remote sensing of air pollutants and green house gases	
			36

Practical Schedule

Exercise No	**Name of the Exercise**
1 - 4	Handling MODIS image products (Reflectance, LAI, fAPAR, LST);
5 -8	Handling SPOT VGT Products, PROSAIL MODEL, ,
9 -11	Retrieval of: LST, Albedo, Radiation,
12 -15	Estimation of Crop Phenology from multi-temporal satellite images, Spectral yield model
16 -18	Remotesensing-based Drought indices and Drought assessment and Spatial Net Primary Productivity modelling.

Course title : Sensors for Soil, Crop and Environment monitoring
Course code : AP 606
Credit Hours : 2+1

Aims of the Course :

To teach the applications of sensors for soil, crop and environment monitoring

Theory

Unit I

Sensing strategies: Traditional field scouting and sampling–laborious and time consuming, Sampling approaches.

Unit II

Sensor platforms and location of sensors: Remote air borne- Satellite, Airplane, UAV (1m to100m); Proximal mobile, earth bound: Continuous moving, Stop-and-go, Proximal & in-situ, stationary Towers. Probes in soil and on crop.

Unit III

Criteria for selecting sensors: Spatial sampling: Extend, coverage, sample area/ volume Temporal: Turnaround time, temporal resolution Data processing: post processing/ real -time Use in management: Predictive / reactive approach Costs Robustness Accuracy Handling: User-friendliness and safety, off-line, on-line, and on-line with map overlay.

Unit IV

Sensors for Environmental Monitoring: 1-Weatherradar, 2- Satellite, 3- Aircraft,4- UAV, 5-Atmospheric, Lidar, 6-Sensor network, 7-Radiometer, 8-Deposition sampler, 9-Atmospheric profiler, 10- Weather station & Eddy - covariance 11- Ground water level monitor, 12-Surface water level monitor, 13- Automatic water sampler, 14 – gas exchange sensor.

Unit V

Soil sensors: Plant nutrients (pools): Macro and Micronutrients, Water content and water potential, Acidity (pH), Buffering, CEC, AEC, Redox Potential,Toxic substances like U, Cd, Pb, Physical properties: Soil strength, Permeability, Porosity Soil biota: Biological activity, pathogens, Organic matter, penetrometers, Geo-electrical sensors, Gamma ray soil sensing, potentiometric sensors, sensors for soilmapping, multi sensors, Visible and near - infrared diffuse reflectance spectroscopy(Vis-NIRS), sensor fusion, hand held XRF.

Unit VI

Plant sensors: Target parameters: Water Potential, Yield quality, Nutrients- macro and micro, Morphology: Biomass, Leaf area, Distribution of plants and organs, Biological threats: disease, pest and weeds, Principles of measurement: (a) mechanical, (b) optical (spectral, spatial resolution, geometry) (c) Acoustics.

Unit VII

Applications in agriculture: Principle of N application based on chlorophyll sensing with spot sensors, On - line application with map - overlay, weed Seeker, Crop Circle & Opt RXWEED it Ag, CropSpec, Fluorescence sensor for agriculture, Laser: Crop morphology - leaf area, Imaging and Non-imaging crop sensors, site specific weed management, hyperspectral video cameras, 3D imaging, stereo vision, sensor based VRT, Thermal imaging, multi reflection ultra-sonic sensor, smart phone based sensors.

Unit VIII

Challenges of sensor technology in agriculture: Direct assessment of relevant properties/ better distinction between various factors, Robustness & user-friendliness, Costs, Data processing and interpretation.

Practical

- Demonstration of various soil sensors, moisture pH, EC monitoring systems,
- Crop sensors-Green seeker, SPAD meters,
- Leaf area meters, line quantum sensors, sensors for environment monitoring - humidity, temperature, radiation recorders.
- Comparison of different sensors, optical, mechanical.

Suggested Reading

- Raphael A. Viscarra Rossel, Alex B. McBratney and Budiman Minasny. 2010. *Proximal Soil Sensing.* Springer Netherlands. ISBN904818858X,9789048188581,

448pages.
- Subhas Chandra Mukhopadhyay.2012. *Smart Sensing Technology for Agriculture and Environmental Monitoring*. Springer. 486pages.
- Vanden Berg E. 2011. *Agricultural sensors*. ASAE publication. ISBN: 0916150984, 9780916150983, 81 pages.

Teaching Schedule
Theory

Sr. No.	Lecture No.	Topics to be covered	Weightage (%)
I	1 - 3	Sensing strategies: Traditional field scouting and sampling – laborious and time consuming, Sampling approaches.	6
II	4 -5	Sensor platforms and location of sensors: Remote air borne-Satellite, Airplane, UAV(1m to100m);	5
	6 -7	Proximal mobile, earthbound: Continuous moving, Stop-and-go, Proximal & in-situ, stationary Towers Probes in soil and on crop.	8
III	8 - 10	Criteria for selecting sensors: Spatial sampling: Extend, coverage, sample area/ volume Temporal: Turn around time, temporal resolution Data processing: post processing/ real- time Use in management:	8
	11 -12	Predictive / reactive approach Costs Robustness Accuracy Handling: User-friendliness and safety, off-line, on-line, and on-line with map overlay.	6
IV	13 - 17	Sensors for Environmental Monitoring:1-Weather radar, 2-Satellite, 3- Aircraft, 4-UAV, 5- Atmospheric, Lidar, 6-Sensor network, 7- Radiometer, 8- Deposition sampler, 9-Atmospheric profiler, 10- Weather station & Eddy -covariance 11- Ground water level monitor, 12- Surface water level monitor, 13- Automatic water sampler, 14- Gas exchange sensor.	12
V	18 - 21	Soilsensors:Plantnutrients(pools):MacroandMicronutrients, Watercontentandwaterpotential,Acidity(pH),Buffering,CEC, AEC,RedoxPotential,Toxic substances like U, Cd, Pb,	10
		Physical properties: Soil strength, Permeability, Porosity Soil biota: Biological activity, pathogens, Organic matter,	
	22 - 25	Penetrometers, Geo-electrical sensors, Gamma ray soil sensing, potentiometric sensors, sensors for soil mapping, multi sensors, Visible and near - infrared diffuse reflectance spectroscopy (Vis-NIRS), sensor fusion, hand held XRF.	9
VI	26 - 27	Plant sensors: Target parameters: Water Potential, Yield quality, Nutrients- macro and micro, Morphology: Biomass,	6

		Leaf area, Distribution of plants and organs,	
	28 -29	Biological threats: disease, pest and weeds, Principles of measurement: (a) mechanical, (b) optical (spectral, spatial resolution, geometry) (c) Acoustics.	8
VII	**30 - 32**	Applications in agriculture: Principle of N application based on chlorophyll sensing with spot sensors, On - line application with map - overlay, weed Seeker, Crop Circle & OptRXWEEDit Ag, CropSpec, Fluorescence sensor for agriculture,	8
	33 - 34	Laser: Crop morphology - leaf area, Imaging and Non-imaging crop sensors, site specific weed management, hyper spectral video cameras, 3D imaging, stereo vision, sensor based VRT, Thermal imaging, multi reflection ultra-sonicsensor, smart phone based sensors.	7
VIII	**35 - 36**	Challenges of sensor technology in agriculture: Direct assessment of relevant properties/ better distinction between various factors, Robustness & user-friendliness, Costs, Data processing and interpretation.	7
			100

Practical Schedule

Exercise No	Name of the Exercise
1 - 9	Demonstration of various soil sensors, moisture pH, EC monitoring systems,
10 -18	Crop sensors-Green seeker, SPAD meters, Leaf area meters, line quantum sensors, sensors for environment monitoring - humidity, temperature, radiation recorders, comparison of different sensors, optical, mechanical.

Course title : Weather Hazards and its Management
Course code : AP 607
Credit Hours : 2+0

Aim of the Course :

To impart knowledge about natural hazards, their management and best practices

Theory

Unit I

Importance & scope of subject in the context of agriculture and developing countries; Concepts, definitions & fundamentals of Hazard, Disaster, Vulnerability, Resilience and Risk

Unit II

Classification of hazards: Natural & Human Induced, Geological–Hydro meteorological – Environmental – Biological, Sudden & creeping, Global and regional trends in hazards; Cycle and Steps in Disaster Management: Risk Management vs crisis management, Activities before, during and after disasters

Unit III

International treaties and mechanisms of disaster management, National institutional mechanisms

Unit IV

Early Warning and Communication system: Characteristics and Components of Early Warning System (formulation, issuance, reception and response), Disaster Specific National and International Early Warning Systems (Drought, Flood, Cyclone, Tsunami), Types of Communication Networks for Disaster Management (Terrestrial, Satellite, Wireless, Mobile), National Disaster Communication System

Unit V

Natural Disasters (Drought, Flood, Cyclone, Heat Wave/ Cold Wave): their preparedness, Early warning & dissemination, response, recovery, mitigation

Unit VI

Biological Disasters (Epidemics, Pest attack of crops and livestock): their preparedness, Early warning & dissemination, response, recovery, mitigation

Unit VII

Risk Transfer and Insurance; Climate Change & Disaster Management

Suggested Reading

- *Disaster Management in India*, Ministry of Home Affairs, Govt. of India, 2011.
- *Manual of Drought Management*, Ministry of Agriculture, Govt. of India, 2016.
- *Textbook of Disaster Management* ,by Nitesh Kumar, Satish Serial Publishing House.

Journals

- *Natural Hazards*
- *Disasters*
- *Agriculture and Forest Meteorology*

Teaching Schedule
Theory

Unit No.	Lecture No.	Topics to be covered	Weightage (%)
I	1- 5	Importance & scope of subject in the context of agriculture and developing countries; Concepts, definitions & fundamentals of Hazard, Disaster, Vulnerability, Resilience and Risk.	10
II	6 -8	Classification of hazards: Natural & Human Induced, Geological–Hydro meteorological – Environmental – Biological, Sudden & creeping,	9
	9 -12	Global and regional trends in hazards; Cycle and Steps in Disaster Management: Risk Management vs crisis management, Activities before, during and after disasters.	10
III	13 -14	International treaties and mechanisms of disaster management, National institutional mechanisms.	9
IV	15 -18	Early Warning and Communication system: Characteristics and Components of Early Warning System (formulation, issuance, reception and response),	12
	19 -21	Disaster Specific National and International Early Warning Systems (Drought, Flood, Cyclone, Tsunami),	10
	22 -25	Types of Communication Networks for Disaster Management (Terrestrial, Satellite, Wireless, Mobile), National Disaster Communication System.	10
V	26 -29	Natural Disasters (Drought, Flood, Cyclone, Heat Wave/ Cold Wave): their preparedness, Early warning & dissemination, response, recovery, mitigation.	12
VI	30 -33	Biological Disasters (Epidemics, Pest attack of crops and livestock): their preparedness, Early warning & dissemination, response, recovery, mitigation.	12
VII	34 -36	Risk Transfer and Insurance; Climate Change & Disaster Management.	6
	Total		**100**

Restructured and Revised Syllabus

M.Sc. (Agriculture)

in

Organic Farming

Submitted by

Broad Subject Coordinator
Associate Dean and Principal
College of Agriculture, VNMKV, Parbhani

Discipline Coordinator
Head & Chief Scientsit
COART, Dr. PDKV, Akola

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Preamble

Although, India had been traditionally organic and its farmers are 40 century farmers with large pool of traditional wisdom on best practices in organic agriculture, the modern standards based organic agriculture started only recently with the growing demand for organic food and fiber in the western world. Movement got major push when civil society organizations and farmer association brought in the focus on sustainability and food safety in the wake of deteriorating soil health and fertility, depleting natural resources, diminishing returns to the farmers and growing chemical residues in food. Growing demand for organic food nationally and internationally with the increased awareness for safe and healthy food further added to the strength of organic farming and attracted the attention of agricultural scientists and planners to look for alternative environment friendly ways which are not only productive enough to meet our growing demands but are also resource conserving and continuously contributing to the improvement of soil health and fertility. Organic agriculture emerged as the viable alternative to all such concerns. Ardent promoters of organic farming consider that present day organic agriculture, which is a mix of traditional wisdom and modern science and technology, can meet all these demands and become the mean for complete development of rural areas, especially in the developing countries like India where large chunk of farmers are small, with limited resources and with limited access to water, mainly through seasonal rains.

Institutional development such as National Programme for Organic production (NPOP) launched during 2001, followed by setting up of National Centre of Organic Farming (NCOF) under Ministry of Agriculture and Farmers Welfare and initiation of Network Project on Organic Farming (NPOF) Research by ICAR during 2004 laid the foundation for systematic development of the sector in the country. Started with just 42,000 ha during 2003-04, it has now grown almost 39-fold, touching a figure of 1.64 million ha during 2017-18. India is now the ninth largest in terms of total arable land under organic farming and largest in terms of total number of organic producers. Market started with exports is also catching up domestically and is now a 5000 crore industry. Dedicated stores and retail chains catering to the demand of organic food can be seen in almost all tier I and tier II cities in the country. But this growth story has also many shortcomings and weaknesses. In the absence of technology and continuous research support, farmers are struggling to maintain yields. Availability of organic seeds and quality inputs for nutrient and pest management is one of the major bottlenecks. Absence of knowledge for diversified cropping systems (a pre-requisite for organic farming) keeps farmers relying on mono-crops which often yields poorly. Absence of trained manpower for extension, certification management and value chain management is also widely experienced and industry make do with less competent experts and personals. To take the organic farming fast forward it is necessary that efforts are made in value chain mode with an aim to transform farmers into entrepreneurs and create an infrastructure that cater to the ever evolving technology needs through research, extension and education. Although a National Organic Farming Research Institute (NOFRI) at Sikkim and some

Institutes of Organic Farming in SAUs has started functioning but still there is lacking of institutions that can cater to the need of trained manpower. ICARs proposal to launch postgraduate programme in organic farming is the first of the efforts to bridge that gap. This report summarizes the recommendations of the committee constituted by the ICAR for drafting the course curriculum for M.Sc. Agriculture in Organic farming: By the end of March 2017, India has brought more than 3.42 million ha area under organic certification, comprising of 1.64 million ha (47.95%) under cultivation and 1.780 million ha (52.05%) under wild harvest collection. India is producing wide range of crops under organic management with oilseeds, sugar crops, fiber crops, cereals and millets and pulses occupy the large chunk of the basket. With mainstreaming of organic farming there is growing requirement for first generation extension personals trained in organic farming. Similarly, for research the country requires first generation scientists with actual organic farming background and passionate-will to work for the sector. As on March 2018 there are more than 3500 grower groups comprising of about 1 million farmers. These groups are known as ICS units and each group comprising of an average of 250-350 farmers and are managed by not less than 5-7 technical persons for documentation management, internal inspections, certification, collective input purchases and sales. Besides third-party certification another farmer group centric certification under PGS-India programme is also certifying farmers. To manage the certification of PGS there are more than 400 Regional Councils and all these require technical manpower, not only in organic crop and livestock management, but also in certification and quality assurance. As on March 2018, there are 28 certification bodies and another 10 are in the pipeline. Each certification body requires an average of 20-150 technical persons. Similarly, for PGS management there are more than 400 Regional Councils requiring more than 4000 technical staff. There are more than 950 organic food processors in the country. As organic system requires complete integrity, therefore processing needs to be dedicated, away from conventional processing units. This is a fast-growing sector and may require large number of organic food professionals in the years to come. Therefore, to feed to the existing and future requirement of technical manpower it is essential that a postgraduate course in organic farming is launched and state Agricultural Universities be encouraged to offer such course.

Minimum Requirements for starting postgraduate course in the University:

1. Faculty

University having Centre of Excellence in Organic farming or having dedicated Institutes for Organic farming are ideal for launching such programme. In cases, if there is no such existing infrastructure then the university must aim to start such Department with multidisciplinary faculty or must be in a position to spare competent faculty for undertaking such course. Initially it may be possible that the institute do not have faculty for each subject, then in such cases faculty may be contracted as visiting faculty for specific course content.

2. Land

As organic farming is a farming system approach, therefore, there is a need for a dedicated organic farm of not less than 5 ha. This farm must be kept organic for long term as frequent switching of land under conventional and organic is not allowed and may not be advisable.

3. Laboratory

There must be fully equipped laboratory for the following:

(i) Soil testing laboratory having facilities for micronutrient analysis along with the usual soil test parameters. Facilities should also be available for estimation of soil microbial carbon, soil enzymatic analysis and soil respiration studies.

(ii) General microbiological laboratory

(iii) General entomology and plant pathology laboratory

(iv) Access to plant analysis equipment and residue analysis laboratories.

Committee Constituted for Finalizing ICAR-NCG-BSMA PG Syllabus of Organic Farming Discipline

ICAR-BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes	Broad Subject Coordinator (Chairman of all Disciplines' SubCommittees)	Discipline Coordinator (Secretary of respective Discipline Sub Committee)
Physical Science	Organic Farming	M.Sc. (Agri.)	Dr. Syed Ismail, ADP, CoA, VNMKV, Parbhani	Dr.A.N.Paslawar Head & Chief Scientsit COART, Dr. PDKV, Akola

Sub-Committee constituted for the finalizing common PG syllabi in Organic Farming Discipline

Sub Committee		
Sr. No.	**Name**	**Designation**
1	Dr. Syed Ismail ADP, CoA, VNMKV, Parbhani Mobile:7588082045 Email: syedismail.ibrahim@gmail.com	Chairman
2	Dr. A. N. Paslawar HOD, Agronomy, Dr. PDKV, Akola Mobile:9822220272 Email: adinathpaslawar@rediffmail.com	Member
3	Dr. A. V. Solanki, HOD Agronomy, MPKV, Rahuri Mobile:9422921816 Email: hodagronomy2014@gmail.com	Member
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7	Dr. Anand Gore Mobile: 7588082874	Member
8	Dr. M. R. Deshmukh, Asstt. Prof., Agronomy, Dr. PDKV, Akola Mobile:9960649696 Email: manish_pkv@rediffmail.com	Member
9	Dr. N.K. Patke, Asso. Prof., Agronomy, Dr. PDKV, Akola Mobile: 7588883506 Email: patkenk@gmail.com	Member
10	Dr. A. N. Paslawar HOD, Agronomy, Dr. PDKV, Akola Mobile:9822220272 Email: adinathpaslawar@rediffmail.com	Member Secretary

Implementation of New Curriculum

The universities offering PG programmes in Organic Farming need to be supported for establishing specialized laboratories equipped with state-of-the art equipments for conducting practical classes especially, Soil Fertility, Water management, Weed management, Conservation Agriculture, Geoinformatics, Pricision Agriculture, Live stock Production and Management, Integrated Farming System etc.

One-time catch-up grant should be awarded to each SAU, offering PG programmes in Agronomy for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. For imparting total quality management, a minimum of two faculty in each department under an SAU should be given on job training in reputed national and international institutes. To execute the new PG. programme in Organic Farming discipline in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of Organic Farming throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of farmers governments, corporate sector and research organization in India and abroad.
- Exposure to the faculty in the latest technical knowhow.

Organization of Course Contents & Credit Requirements

- ❖ Minimum Residential Requirement
  M.Sc.: 4 Semesters
- ❖ Name of the Departments / Divisions
  Organic Farming
- ❖ Nomenclature of Degree Programme
  M.Sc. Programme
  M.Sc. (Agriculture) Organic Farming

Code Numbers

- ❖ All courses are 500-series courses an pertain to Master's level.
- ❖ Credit Seminar for Master's level is designated by code no. 591.
- ❖ Master's research: 599

Course Content

- ❖ The contents of each course have been organized into:
- ❖ Objective – to elucidate the basic purpose.
- ❖ Theory units – to facilitate uniform coverage of syllabus for paper setting.

- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner

Eligibility for Admission

- Master's Degree Programme
- Bachelor's degree in respective discipline under 10+2+4 system with minimum of 5.50/10 or equivalent percentage of marks and based on CET score
- Provision: If some seats are lying vacant then B.Sc. Graduates from other streams under 10+2+4 system may be considered for admission, however, they will have to undergo the Deficiency course package.
- B.Sc.(Agri.) / B. Sc. (Hons.) Agriculture/ B. Sc. (Hort.)/ B.Sc. (Hons.) Horticulture/ B. Sc. (Forestry)/ B.Sc. (Hons.) Forestry, or equivalent degree with four years duration of agriculture related Universities and having the Common Entrance Test in Forestry conducted by competent authority.

(Note:- In case B.Sc. (Hons.) Agriculture; candidates are not available, B.Sc. Ag / B.Sc. Hort. may be considered subjected to completion of deficiency package.

Credit Requirements

Course Details	**Master's Degree**
Major Courses	20
Minor Courses	08
Supporting / Optional	06
Common PGS Courses	05
Seminar	01
Research	30
Total	**70**

M.Sc. (Agri) Organic Farming
Course Structure

LIST OF CORE COURSES / DEPARTMENT WISE SPECIALIZATION/ COMPULSORY/ SUPPORTING COURSES

Course code	**Semester**	**Course Title**	**Credits Hrs.**
OF 501*	**I**	Concept and principal of organic farming	**2+0=2**
OF 503*	**I**	Organic crop production systems	**2+1 =3**
OF 505	**I**	Post harvest handling of organic produce	**1+1=2**
OF 502*	**II**	Soil fertility ,Crop Production and Nutrients input	**3+1=4**
OF 504*	**II**	Plant Health Management	**2+1=3**
OF 506	**II**	Farming system suitable for organic managements	**2+1=3**
OF 507	**III**	Organic certification Standards and regulation	**2+1=3**
OF 508	**III**	Value Chain Management	**2+2=4**
OF 509	**II**	Marketing	**2+0=2**
OF 510	**I**	Research Methodology and Biostatistics	**2+1=3**
OF 511	**III**	Organic Input Management and Production Technologies	**2+1**
OF 591	**IV**	**Master's Seminar**	**1+0 =1**
OF 599		**Master's Research**	**0+30**

❖ **Compulsory Courses**

Major 20 + Minor 08+ Supporting 06 + NCCC 05 + Seminar 01+ Research 30 = 70

Semester wise course layout for M.Sc.(Agri) in Organic Farming (ICAR-NCG-BSMA New Syllabus)

Course No	Title of Course	Credit	Remark
Semester I			
OF 501*	Concept and principal of organic farming	**(2+0=2)**	Major
OF 503*	Organic crop production systems	**(2+1=3)**	Major
OF 505	Post harvest handling of organic produce	**(1+1=2)**	Major
AH501	Livestock Production Management	**(2+1=3)**	Minor
PGS 501	Library and Information Services	, **(0+1=1)**	PGS
PGS 504	Basic Concepts in Laboratory Techniques	**(0+1=1)**	PGS
OF 510	Research Methodology and Biostatistics	**(2+1=3)**	Major
SOIL 506	Soil Biology and Biochemistry	**(2+1=3)**	Minor
	Total	**11+7=18**	
Semester II			
OF 502*	Soil fertility ,Crop Production and Nutrients input	**(3+1=4)**	Major
OF 504*	Plant Health Management	**(2+1=3)**	Major
OF 506	Farming system suitable for organic managements	**(2+1=3)**	Major
OF 509	Marketing	**(2+0=2)**	Major
PGS 502	Technical Writing and Communications Skills	**(0+1=1)**	PGS
PGS 503	Intellectual Property and its management in Agriculture	**(0+1=1)**	PGS
STAT 511	Experimental Designs	(2+1=3)	Supporting
		11+7=18	

Semester III			
OF 507	Organic certification Standards and regulation	**(2+1=3)**	Major
OF 511	Organic Input Management and Production Technologies	**(2+1=3)**	Major
OF 508	Value Chain Management	**(2+2=4)**	Major
OF 511	Organic Input Management and Production Technologies	**(2+1=3)**	Supporting
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	**1+0**	PGS
OF 591	Masters Seminar	**0+1**	Major
OF 599	Masters Research	**0+5**	
		9+11=20	
Semester IV			
OF 599	Masters Research	**0+15**	Major
		0+15	

Common Courses: (Non-Credit)

Course code	Semester	Course Title	Credits
PGS 501	I	Library and Information Services	**0+1**
PGS 504	I	Basic Concepts in Laboratory Techniques	**0+1**
PGS 502	II	Technical Writing and Communications Skills	**0+1**
PGS 503	II	Intellectual Property and its management in Agriculture	**1+0**
PGS 505	III	Agricultural Research, Research Ethics and Rural Development Programmes	**1+0**
		Total	**2+6=8**

Optional / Supporting Courses

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agricultural Metrology
3. Soil Science
4. Agronomy
5. Biochemistry
6. Horticulture
7. Forestry
8. Computer Science and Information Technology

Course Code	Semester	Course Title	Credit Hrs.
STAT 511	II	Experimental Designs	2+1=3
AGRON 505	I	Conservation Agriculture	(1+1)
AGRO 513	II	Principles and practices of organic farming	(2+1)
SOIL 512	I	Land degradation and restoration	(1+0)

Minor Disciplines:

- Natural Resource Management
- Seed Science and Technology
- Plant Physiology
- Agricultural Marketing
- Soil Science
- Animal Husbandary

- Plantation, Spices, Medicinal and Aromatic Crops
- Biochemistry Food Technology
- Microbiology
- Plant Protection

Suggestive minor or supporting courses

Course Code	Course Title	Credit Hrs.
SOIL 501	Soil Physics	2+1=3
SOIL 509	Remote sensing and GIS technique for soil and crop studies	2+1=3
SOIL 504	Soil mineralogy, genesis and classification	2+1=3
AGM 503	Crop-weather Relationships	2+0=2
AGM 512	Weather and climate risk management	2+0=2
MICRO 505*	Soil microbiology	2+1=3
MICRO 511	Biofertilizer technology	2+1=3
PP 501*	Principles of Plant Physiology-I: Plant Water Relations	2+1=3
PP 508	Physiology of Field Crops	2+0=2
PP 510*	Seed Physiology	2+1=3
AH 501	Live Stock Production and Management	2+1=3
SOIL 506	Soil Biology and Biochemistry	2+1=3

Course Title with Credit Load, M.Sc. (Ag.) in Organic Farming

Course Code.	Course Title	Credit Hours
OF 501	Concepts and Principles of organic farming	**2+0**
OF 502	Soil fertility, Crop Nutrition and Nutrients input	**3+1**
OF 503	Organic Crop Production Systems	**2+1**
OF 504	Plant Health Management	**2+1**
OF 505	Post harvest handling of organic produce	**1+1**
OF 506	Farming systems suitable for organic managements	**2+1**
OF 507	Organic certification Standards and regulation	**2+1**
OF 508	Value Chain Management	**2+2**
OF 509	Marketing	**2+0**
OF 510	Research Methodology and Biostatistics	**2+1**
OF 511	Organic Input Management and Production Technologies	**2+1**
OF 591	Masters Seminar	**1+0**
OF 599	Masters Research/ Thesis	**0+30**

Compulsory Non Credit Deficiency Courses (those who are non Agricultural Graduates)
Students from Non Agriculture stream will be required to completed Non credit deficiency courses (6-10 credits) from the courses related to the discipline in which admitted and as decided by the Student Advisory committee.

Sr. No.	Semester	Course No.	Credits	Course Title
1	**I**	AGRO 234	2(1+1)	Crop Production Technology-I (Kharif crops)
	II	AGRO 248	2(1+1)	Principles of Organic Farming
2	II	AGRO 246	2(1+1)	Crop Production Technology-II (Rabi crops)
	I	H AGRO 351	2(1+1)	Organic Farming
3	III	AGRO 359	1(0+1)	Practical Crop Production-I (Kharif crops)
4	III	ELE AGRO 3510	3(2+1)	Weed Management
5	II	AGRO 3611	1(0+1)	Practical Crop Production-II (Rabi crops)

I. Course Title	**Concepts and Principles of Organic Farming**
II. Course Code	OF 501
III. Credit Hours	2+0
IV. Aim of the course	To impart knowledge on the basic concept of organic farming

UNIT	Proposed Course Content
I	Concepts and principles of organic farming History and evolution of organic farming in the world and India. Scenario of organic farming in India and world, global market for organic products, General principles of organic farming, conversion to organic agriculture, advantages and limitations.Key indication of sustainable agriculture.
II	Definitions and types of organic farming Definitions of organic farming, types of organic farming such as natural farming, zero chemical natural farming, bio dynamic farming, biological farming, compost farming, Natueco culture, integrated farming, homa farming, yogic farming, ZBNF, permaculture etc, traditional farming systems in India and evolving indigenous knowledge systems
III	**Conventional vs Organic farming** Adverse effects of conventional farming philosophy of two farming systems, fundamental differences, productivity issues, management protocols, food quality, nutritional differences and impact on soil fertility, natural resources, environment and overall social perception. Myths and realities about organic farming in improving soil health and enviromenment and addressing nutritional security and food safety need vis-à-vis national food security.
IV	**Advocacy, Ethics, health and social issues in organic farming** Advocacy for organic farming with sustainability, resource conservation and food safety issues. Advocacy through overall farm productivity under diversified cropping systems. Spirituality values and ethics in organic farming. Socio economic importance of organic farming: concept measurements and issues. Spirituality values and ethics in organic farming and need for ethical practices and values across the organic agriculture value chain including trading and reaching to consumers.
v	**Organic farming for sustainability, resource conservation, climate change issues and safe and healthy food** General concerns on sustainability, climate change issues threatening sustainability, potential of organic farming practices in addressing sustainability and climate change. Resource conservation through organic farming, soil and rainwater conservation and preservation of native seeds and germplasm an essential component of organic farming, Consumers concerns on food quality and safety, organic farming for safe and healthy food, ITKs potential and role in sustainability of modern organic farming practices

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on organic farming so as to be an organic trainer, promoter and grower.

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition.
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Published by Jain Brothers
- *Basics of Organic Farming:* Deshpande, WR, 2009, All India Biodynamic and Organic Farming Association, Indore, MP, India P-306.

- Eyhorn, F, Heeb M and Weidmann, Gilles IFOAM *Training Manual for Organic Agriculture in the Tropics*, FiBL and IFOAM.

Teaching Schedule

Lecture	Topic	Weightage (%)
1.	Concepts and principles of organic farming- History and evolution of organic farming in the world and India	8
2.	Scenario of organic farming in India and world, global market for organic products	8
3.	General principles of organic farming, conversion to organic agriculture, advantages and limitations. Key indication of sustainable agriculture.	10
4	Initiative taken by Govt, NGO and Organizations for promotion of Organic Agriculture	8
5 and 6	Definitions of organic farming, types of organic farming such as natural farming, zero chemical natural farming, bio dynamic farming,	10
7 and 8	biological farming, compost farming, Natueco culture, integrated farming, homa farming, yogic farming, ZBNF, permaculture etc,	10
9.	Traditional farming systems in India and evolving indigenous knowledge systems	6
10.	Conventional vs Organic farming- Adverse effects of conventional farming philosophy of two farming systems.	4
11 and 12.	Fundamental differences, productivity issues, management protocols, food quality, nutritional differences and impact on soil fertility, natural resources, environment and overall social perception.	8
13 and 14	Myths and realities about organic farming in improving soil health and environment and addressing nutritional security and food safety need vis-à-vis national food security.	8
15.	Advocacy, Ethics, health and social issues in organic farming- Advocacy for organic farming with sustainability,	4
16.	Resource conservation and food safety issues. Advocacy through overall farm productivity under diversified cropping systems.	4
17.	Spirituality values and ethics in organic farming. Socio economic importance of organic farming: concept measurements and issues.	4
18.	Spirituality values and ethics in organic farming and need for ethical practices and values across the organic agriculture value chain including trading and reaching to consumers	8
	Total	100

I. Course Title	**Soil Fertility, Crop Nutrition and Nutrient Inputs**
II. Course Code	OF 502
III. Credit Hours	3+1
IV. Aim of the course	To provide knowledge on fertility of soil and also different organic inputs to be used in organic farming

Theory

UNIT	Proposed Course Content
I	Source of Infinite Life Soil as source of life, fundamentals of soil structure and quality, soil fertility, physico-chemical properties of soil as living entity in organic farming.
II	Soil fertility and productivity History of soil fertility and plant nutrition. Factors affecting; features of good management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.
III	Soil fertility evaluation Physico-chemical soil testing, biological methods for soil health evaluation, plant and tissue tests; soil quality in relation to sustainable agriculture. Nutrient requirement modeling based on soil health and resources availability.
IV	Soil Conservation and Soil Water Management Principles of soil and water conservation, general practices for soil and water conservation, their role in organic farming, soil carbon build up, concept of carbon credit and biomass recycling.
V	Soil biology and role of microorganisms in soil fertility management Soil as a habitat for microorganisms, Soil microorganisms, Soil microbial ecology, Soil microbial biomass, Soil enzymes – origin, activity and importance. Use of soil microbes and microbial management of agricultural, domestic and industrial wastes for potential application in organic farming. Microbiology of composting and bio-methanation. Biodegradation of xenobiotics. Bioremediation – principles and application.
VI	Nutrient recycling Nitrogen, phosphorus and potash cycles, management for nutrient recycling, methods for recycling and reducing nutrient losses.
VII	Management practices Management practices in organic agriculture (mulching, fallowing, intercropping. Biological weed management, mixed cropping and multi storied cropping. Multitier cropping system, manuring, green manuring. crop rotation, agro-forestry, mixed farming).
VIII	Organic fertilizers and composting technology organic fertilizer, types and sources of organic manures, compositing principles and factors affecting composting, dynamics of compositing, methods of composting, different forms of composts with nutrient profiles, Rapid methods of composting, liquid manures, compost enrichment through concentrates, minerals and micronutrients. Field application of compost and their response to crops.
IX	Vermicomposting technology Earthworm biology, principles of vermicomposting, methods for vermicompost and vermiwash production, nutrient profiling, field application and its response to crop yields

X	Biofertilizers Different types of biofertilizers, their contribution to soil fertility and nutrient pool, factors affecting their application and response, assessment of biofertilizers application to crop yields.
XI	Addressing nutrient deficiencies and mineral fortification of composts (P, K, S and micro nutrients) Identification of deficiency, need assessment, identification of mineral resource, fortification of composts and impact assessment on application
XII	Indigenous practices in soil fertility and nutrient management and enchancing soil microflora Indigenous inputs such as liquid manures, Jivamrit, bijamrut, Panchgavya, dashgavya, on-farm protein hydrolysates, plant extracts, dung-urine slurries etc, their production methods and effect of their application on soil fertility and crop productivity.

Practical

- Introduction of analytical instruments and their principles, calibration and applications, Determination of soil pH, electrical conductivity, organic carbon, total and available nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and DTPA extractable micronutrients in soil and their interpretations.
- Biological health assessment through dehydrogenases, soil microbial carbon and soil respiration
- Making of composts through aerobic and anaerobic methods
- Making of vermicomost using earthworms
- Analysis of manures and composts for NPK and heavy metals\
- Microbial profiling of Jivamrit/ panchgavya

Teaching Schedule

Lecture	**Topic**	**Weightage (%)**
1.	Source of Infinite Life- Soil as source of life, fundamentals of soil structure and quality, soil fertility.	4
2.	Physico-chemical properties of soil as living entity in organic farming.	4
3	Soil fertility and productivity- History of soil fertility and plant nutrition. Factors affecting; features of good management.	4
4	Problems of supply and availability of nutrients; relation between nutrient supply and crop growth; Criteria of essentiality of nutrients;	4
5	Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.	4
6	Soil fertility evaluation- Physico-chemical soil testing, biological methods for soil health evaluation, plant and tissue tests;	4
7	Soil quality in relation to sustainable agriculture.	4
8	Nutrient requirement modeling based on soil health and resources availability.	4
9	Soil Conservation and Soil Water Management- Principles of soil and water conservation, general practices for soil and	4

	water conservation, their role in organic farming,	
10	Soil carbon build up, concept of carbon credit and biomass recycling.	4
11 and 12	Soil biology and role of microorganisms in soil fertility management- Soil as a habitat for microorganisms, Soil microorganisms, Soil microbial ecology, Soil microbial biomass,	4
13	Soil enzymes – origin, activity and importance.	4
13 And 14	Use of soil microbes and microbial management of agricultural, domestic and industrial wastes for potential application in organic farming.	4
15	Microbiology of composting and bio-methanation. Biodegradation of xenobiotics. Bioremediation – principles and application.	4
16	Nutrient recycling- Nitrogen, phosphorus and potash cycles, management for nutrient recycling, methods for recycling and reducing nutrient losses.	4
17 and 18	Management practices- Management practices in organic agriculture (mulching, fallowing, intercropping. Biological weed management mixed cropping and multi storied cropping.	4
19	Multitier cropping system, manuring, green manuring. crop rotation, agro-forestry, mixed farming).	4
20 and 21	Organic fertilizers and composting technology-Organic fertilizer, types and sources of organic manures, compositing principles and factors affecting composting, dynamics of compositing, methods of composting, different forms of composts with nutrient profiles,	8
22	Rapid methods of composting, liquid manures, compost enrichment through concentrates, minerals and micronutrients. Field application of compost and their response to crops.	4
23 and 24	Vermicomposting technology-Earthworm biology, principles of vermicomposting, methods for vermicompost and vermiwash production, nutrient profiling, field application and its response to crop yields	8
25	Biofertilizers-Different types of biofertilizers, their contribution to soil fertility and nutrient pool, factors affecting their application and response, assessment of biofertilizers application to crop yields.	4
26 and 27	Addressing nutrient deficiencies and mineral fortification of composts (P, K, S and micro nutrients)-Identification of deficiency, need assessment, identification of mineral resource, fortification of composts and impact assessment on application	4
28 and 29	Indigenous practices in soil fertility and nutrient management and enchancing soil microflora-Indigenous inputs such as liquid manures, Jivamrit, bijamrut, Panchgavya, dashgavya, on-farm protein hydrolysates, plant extracts, dung-urine slurries etc, their production methods and effect of their application on soil fertility and crop productivity.	4

	Total	100

Practicals

Experment No.	**Practical Exercises**	**Weightage (%)**
1 & 2	Introduction of analytical instruments and their principles Calibration and applications	**5**
2 & 3	Determination of soil pH, electrical conductivity, organic carbon, total and available nitrogen, phosphorus. Potassium calcium.	**5**
4 & 5	Magnesium, sulphur and DTPA extractable micronutrients in soil and their interpretations.	**5**
6	Biological health assessment through dehydrogenases, soil microbial carbon and soil respiration	**5**
7, 8 & 9	Making of composts through aerobic and anaerobic methods	**8**
10, 11 & 12	Making of vermicomost using earthworms	**7**
13, 14 & 15	Analysis of manures and composts for NPK and heavy metals	**7**
16	Microbial profiling of Jivamrit/ panchgavya	**8**
	Total	**50**

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on soil fertility and management in organic farming

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers
- *Manufacture of Biofertilizer and Organic Farming*. AB publisher

I. Course Title	**Organic Crop Production systems**
II. Course Code	OF 503
III. Credit Hours	2+1
IV. Aim of the course	To provide knowledge on organic crop production system

Theory

UNIT	Proposed Course Content
I	Fundamentals of organic farm management and conversion Salient features of organic farm management, lay out and planning for development of organic farm, strategies for conversion to organic, step-by-step planning, integration of contamination control measures, integrated planning for various important components like land preparation and separation, farm building, planning for on-farm input production and supplementary off-farm inputs, planning for rain water harvesting and water conservation approaches including efficient irrigation systems and moisture conservation techniques.
II	Management of diversity and cropping systems Importance of diversity, installation of diversity through plantation of utility trees, nitrogen fixing tree hedges, habitat management for friendly insects and birds and nitrogen fixing crops as intercrops. Importance of cropping systems management with long term planning, crop rotations, intercropping, multi cropping, relay cropping, multi-layered cropping.
III	Nutrient management Components of nutrient management in organic crop production, assessment of crop nutrient requirements, calculation of nutrient credits from on-farm practices and resources such as intercrops, cover crops, biomass mulching, calculating additional input requirements. Managing nutrient needs through use of organic manures, viz. FYM, compost, Vermicompost, oil cakes, *in-situ* and *ex-situ* green manuring, crop residue management, use of restricted organic nutrient sources, liquid organic manures and dung urine slurries, Biogas slurry, methods of manuring and biomass application, maechanization in composting and biomass conservation, liquid manures, foliar feeding as replacement of top dressing, ITKs and farmers innovations in nutrient management
IV	Integration of microbial and mineral inputs Importance of bio fertilizers, types of biofertilizers, nutrient potential, methods of application, enriching manures/ composts with biofertilizers, identifying the need for use of supplementary mineral sources and their integration in nutrient management package.
V	Weed management Prevention of weeds through tillage oprations and cropping systems management, crop geometry, stale seedbed technique, soil solarisation, cover crops, mulching, flooding, biological weed management, selection of suitable physical and mechanical approaches and biological and plastic mulches, use of plant extracts in weed management, weed manuring.
VI	Water and Irrigation Management Soil-water relation, theories of water availability, water use efficiency management, methods of irrigation and automation in irrigation systems, biofertigation management. Water quality irrigation scheduling in different crops
VII	Modeling of agronomic practices and nutrient management protocols for some important agricultural and horticultural crops Identification of compatible associate and intercrops/ companion crops, placing trap

	crops and insectary plants in cropping geometry, making provisions for nutrient credits from biomass mulching, intercrops and green manures, making provisions for nutrient credits from microbial enrichment with microbial/ liquid manure inputs, balance nutrient requirement modeling and identification of inputs and planning for quantity and time of application.
VIII	Crop growth and yield analysis Crop growth expressions in plants, growth measurements, important growth indices and forms of growth analysis in field crops. Factors determining yield. Use of growth analysis technique to study variation in yield due to planting season, planting density, manures application, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.
IX	Success stories of effective crop management with optimum yields of practicing organic farmers (one in irrigated systems and one in rainfed systems) Documentation of farming system with inputs and outputs, identification of practices important for organic systems, nutrient management practices, pest management protocols, yields and economics. Salient features for success and for further replication in crop production modeling.

Practical

- Visit to organic farms, units and study general nutrient management practices, Best management practices, documentation of farming system with inputs and outputs and crop growth analysis using crop growth analysis techniques
- Getting acquainted with different tilling methods and rain water harvesting and water conservation techniques
- Production of liquid manures and dung-urine slurries
- Production of customized composts using FYM/ Compost, mineral nutrients and biofertilizers, assessment of nutrient profiles in enriched composts
- Methods of application for biofertilizers
- Weed management practices, tools and efficacy of different approaches
- Modelling of agronomic practices for a given cropping system with use of available resources.
- Collection of seeds & preparation of seed album of deshi crops & varieties.
- Quantification metods of manures application.

Teaching Schedule

Lecture	Topic	Weightage (%)
1.	Fundamentals of organic farm management and conversion Salient features of organic farm management, lay out and planning for development of organic farm, strategies for conversion to organic, step-by-step planning,	4
2.	Integration of contamination control measures, integrated planning for various important components like land preparation and separation, farm building, planning for on-farm input production and supplementary off-farm inputs, planning for rain water harvesting and water conservation approaches including efficient irrigation systems and moisture conservation techniques.	8
3	Management of diversity and cropping systems-	4

	Importance of diversity, installation of diversity through plantation of utility trees, nitrogen fixing tree hedges, habitat management for friendly insects and birds and nitrogen fixing crops as intercrops.	
4	Importance of cropping systems management with long term planning, crop rotations, intercropping, multi cropping, relay cropping, multi-layered cropping.	4
5	Nutrient management- Components of nutrient management in organic crop production, assessment of crop nutrient requirements, calculation of nutrient credits from on-farm practices and resources such as intercrops, cover crops, biomass mulching, calculating additional input requirements.	8
6	Managing nutrient needs through use of organic manures, viz. FYM, compost, Vermicompost, oil cakes, in-situ and ex-situ green manuring, crop residue management, use of restricted organic nutrient sources, liquid organic manures and dung urine slurries, Biogas slurry,	4
7	Methods of manuring and biomass application, maechanization in composting and biomass conservation, liquid manures, foliar feeding as replacement of top dressing, ITKs and farmers innovations in nutrient management	8
8	Integration of microbial and mineral inputs- Importance of bio fertilizers, types of biofertilizers, nutrient potential, methods of application, enriching manures/ composts with biofertilizers, identifying the need for use of supplementary mineral sources and their integration in nutrient management package.	8
9	Weed management- Prevention of weeds through tillage oprations and cropping systems management, crop geometry, stale seedbed technique, soil solarisation, cover crops, mulching, flooding,	4
10	Biological weed management, selection of suitable physical and mechanical approaches and biological and plastic mulches, use of plant extracts in weed management, weed manuring.	4
11	Water and Irrigation Management- Soil-water relation, theories of water availability, water use efficiency management, methods of irrigation and automation in irrigation systems, biofertigation management. Water quality irrigation scheduling in different crops	8
12 and 13	Modeling of agronomic practices and nutrient management protocols for some important agricultural and horticultural crops- Identification of compatible associate and intercrops/ companion crops, placing trap crops and insectary plants in cropping geometry,	8
14	Making provisions for nutrient credits from biomass mulching, intercrops and green manures, making provisions for nutrient credits from microbial enrichment with microbial/ liquid manure inputs, balance nutrient	8

	requirement modeling and identification of inputs and planning for quantity and time of application.	
15	Crop growth and yield analysis Crop growth expressions in plants, growth measurements, important growth indices and forms of growth analysis in field crops. Factors determining yield.	4
16 and 17	Use of growth analysis technique to study variation in yield due to planting season, planting density, manures application, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.	8
18	Success stories of effective crop management with optimum yields of practicing organic farmers (one in irrigated systems and one in rainfed systems)- Documentation of farming system with inputs and outputs, identification of practices important for organic systems, nutrient management practices, pest management protocols, yields and economics. Salient features for success and for further replication in crop production modeling.	8
	Total	100

Practical Schedule

Experiment	**Topic**	**Weightage (%)**
1.	Visit to organic farms, units and study general nutrient management practices, Best management practices, documentation of farming system with inputs and outputs and crop growth analysis using crop growth analysis techniques	**5**
2.	Getting acquainted with different tilling methods and rain water harvesting and water conservation techniques	**5**
3.	Production of liquid manures and dung-urine slurries	**5**
4.	Production of customized composts using FYM/ Compost, mineral nutrients and biofertilizers, assessment of nutrient profiles in enriched composts	**5**
5.	Methods of application for biofertilizers	**5**
6.	Weed management practices, tools and efficacy of different approaches	**7**
7.	Modelling of agronomic practices for a given cropping system with use of available resources.	**5**
8.	Collection of seeds & preparation of seed album of deshi crops & varieties.	**8**
9.	Quantification metods of manures application.	**5**
	Total	**50**

Teaching methods/activities Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome Basic knowledge on organic crop production system
Suggested Reading • Basics of Organic Farming: by Mamta Bansal. Kindle Edition • The Complete book of Organic farming and products of organic compost: NPCS Board of consultants and Engineers. • ABC of Organic Farming: Amitava Rakshit and H.B. Singh. Jain Brothers.

I. Course Title	**Plant Health Management**
II. Course Code	OF 504
III. Credit Hours	2+1
IV. Aim of the course	To provide knowledge on plant health management for optimization of crop yield due to organic farming

Theory

UNIT	Proposed Course Content
I	Classification of pest organisms Classification of pests, viz. weeds, bacteria, nematodes, fungi, insects, viruses, vertebrates, *etc*, identification of pests and beneficial organisms.
II	General principles of plant health management in organic farming Principles of pest management in organic crop production; Pest surveillance and pest population estimation; concept of economic injury levels (EILs) and economic threshold levels (ETLs), principles of Agro Eco-System Analysis (AESA) based pest management, estimation of Pest: Defender (P: D) ratio, understanding AESA methodology.
III	Biology of pests and population dynamics Population dynamics in relation to environment, distribution, identification; Life cycle of key pests of cereals, pulses, vegetables, stored grains, fruit crops and protected cultivation.
IV	Ecological strategies for pest management Proper sanitation, appropriate nutrient management, necessary pruning, timing of planting to escape infection, crop rotation, avoidance of endemic sites, space management for sunlight and air, plant quarantine, *etc*.
V	Cultural and physical control strategies Importance and use of traps (light trapes, solar trapes), coloured plates, pheromones, use of insectary plants, trap crops and planning for diversity plant integration as border crops, hedge rows, intercrops, *etc*.
VI	Biological control Conservation of natural enemies, classical biological control systems, important beneficial insects and their integration and use in different cropping systems.
VII	Biopesticides Biopesticides, types, mode of action, production, methods of application and impact assessment on crops and pest load.
VIII	Botanical pesticides Using different plants for management of different pests, methods for using such plants and active ingredient extraction methodologies, formulation of usable solutions and methodologies for application. Integrated strategies, development of crop specific integrated management modules, importance and need for chemical alternatives permitted in organic farming, methods for use and application.
IX	Indigenous practices and their importance in plant protection Indigenous practices of avoiding pests, managing pests, important plants being used since ages and innovative botanical and fermentation inputs developed by farmers for pest management.
X	Pest control of produce in storage Physical, mechanical and biological approaches, modified environment, management of

	hygiene and phyto-sanitary approaches, use of organically acceptable fumigants such as carbon dioxide and nitrogen. ITKs in storage pest management.

Practical

- Collection and Identification of major/ key pests and plant diseases,
- Estimation of pest population, nature of damage, assessment of crop losses,
- Familiarization with important crop pests & diseases and their biological control agents,
- Demonstration/ familiarization with various tools of insect-pest & disease management,
- Mass rearing techniques of important biological control agents,
- Preparation of organic/ natural formulations for insect-pest & disease management,
- Evaluation of organic formulations for determining their pesticidal properties and field efficacy.
- Preparation and validation of traditional formulations.
- Economics of value added products.

Teaching Schedule

Lecture	Topic	Weightage (%)
1 & 2	Classification of pests, viz. weeds, bacteria, nematodes, fungi, insects, viruses, vertebrates, etc, identification of pests and beneficial organisms.	6
3.	Principles of pest management in organic crop production.	8
4.	Pest surveillance and pest population estimation; concept of economic injury levels (EILs) and economic threshold levels (ETLs).	6
5.	Principles of Agro Eco-System, Analysis (AESA) based pest management, estimation of Pest: Defender (P:D) ratio, understanding AESA methodology.	6
6.	Biology of pests and population dynamics of pests in relation to environment, distribution, identification..	6
7.	Life cycle of key pests of cereals, pulses, vegetables, stored grains, fruit crops and protected cultivation	6
8.	Ecological strategies for pest management, proper sanitation, appropriate nutrient management, necessary pruning, timing of planting to escape infection, crop rotation etc.	8
9.	Avoidance of pest endemic sites, space management for sunlight and air, plant quarantine and other preventive measures in ecological pets management strategies.	6
10.	Cultural and physical control strategies for pest management, importance and use of traps (light trapes, solar trapes),coloured plates, pheromones etc.	8
11.	Use of insectary plants, trap crops and planning for diversity plant integration as border crops, hedge rows, intercrops, etc. under cultural and physical control strategies.	6
12.	Biological controland classical biological control systems for pest management.	8
13.	Use of natural enemies in biological pest management, conservation of natural enemies, their integration and use in different cropping systems for	8

	pest management.	
14.	Biopesticides, types of bio pesticides, mode of action, production, methods of application and effect on crops and pests.	6
15 & 16	Using different plants for management of different pests, methods for using such plants and active ingredient extraction methodologies, formulation of usable solutions and methodologies for application.	6
17.	Integrated strategies for pest management, development of crop specific integrated pest management modules, importance and need for chemical alternatives permitted in organic farming, methods for use and application.	6
	Total	100

Practical

Exercise	**Topic**	**Weightage (%)**
1.	Collection and Identification of major/ key pests and plant diseases.	5
2.	Estimation of pest population, nature of damage, assessment of crop losses,	5
3.	Familiarization with important crop pests & diseases and their biological control agents,	5
4.	Demonstration/ familiarization with various tools of insect-pest & disease management,	5
5	Mass rearing techniques of important biological control agents,	5
6	Preparation of organic/ natural formulations for insect-pest & disease management,	7
7	Evaluation of organic formulations for determining their pesticidal properties and field efficacy.	5
8	Preparation and validation of traditional formulations.	8
9.	Economics of various inputs/products/methodologies/practices.	5
	Total	**50**

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Plant health will be taken care of for optimization of higher crop yield due to organic farming

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher

I. Course Title	**Post Harvest-handling of Organic Produce**
II. Course Code	OF 505
III. Credit Hours	1+1
IV. Aim of the course	To provide knowledge on post harvest handling of organic produce for optimization of crop yield due to organic farming

Theory

UNIT	Proposed Course Content
I	Pre/Postharvest Factors for Post-harvest Losses of Organic Produce Pre and post-harvest factors responsible for causing organic produce losses. Principles and practices responsible for losses of organic agricultural produce. Qualitative, quantitative, nutritional and socioeconomic losses. Loss assessment and estimation techniques and their limitations and methods for reducing postharvest losses.
II	Introduction to Value Chain and Handling of Fresh Organic Products for Processing Management of hygiene and phyto-sanitary measures, measures to reduce field heat, cleaning and washing, control of enzymatic and non-enzymatic changes, Natural sources of antioxidants for health defence, transportation, sorting, grading, peeling, sampling and size reduction, packaging, labelling; handling methods for fresh fruits, vegetables and flowers.
III	Organic Food Processing and Preservation Fundamental principles for food processing in organic farming, acceptable processing techniques, use of preservatives, processing aids, flavouring agents and nutrient supplement in organic food and feed processing.
IV	Food Standards and Residue Analysis/ Toxicology Fundamental principles of food standards, HACCP system, US and European and other countries. Export/ Import standards for different crops, MRLs, sources of contamination, assessment and management of residues and toxins in food, critical control points, heavy metals and pesticide residue analysis, analytical methods and tools. Interpretation of residue analysis reports, analysis protocols and GMO report analysis.
V	Principles of Packaging Characteristics of packaging materials for organic food, packaging requirements for fresh and processed organic food for local and international markets, labelling requirements for fresh and processed organic food for local and international markets, labelling requirements and management integrity.

Practicals

- Study of maturity indices for harvest of organic fruits, vegetables, spices and plantation crops, Edible wax.
- Comparative study of maturity indices for harvest of organic and conventionally grown fruits, vegetables, spices and plantation crops.

- Determination of physiological loss in weight and respiration rate in fruits and vegetables.
- Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/ vegetables.
- Protective skin coating with organic wax emulsion to extend the shelf life of fruits and vegetables.
- Study of effect of precooling on shelf-life and quality of fresh fruits, vegetables and flowers.
- Study of packages-bulk and consumer packs for different fruits, vegetables, flowers and spices.
- Study of construction and working of zero energy cool chamber. Study of storage behaviour of different fruits and vegetables in zero energy cool chamber.
- Preparation and preservation of fruit-based beverages and blended products from fruits and vegetables.
- HACCP analysis, residue analysis in organic products. Visit to packaging centres, local markets, cooperative organisations, super markets dealing with marketing of organic perishables.

Teaching Schedule

Lecture	Topic	Weightage (%)
1	Losses caused by pre and post-harvest factors in organic produce. Factors affecting losses caused in organic agricultural produce.	6
2.	Qualitative, quantitative, nutritional and socioeconomic losses. Loss assessment and estimation techniques and their limitations and methods for reducing postharvest losses.	6
3.	Management of hygiene and phyto-sanitary measures, measures to reduce field heat, cleaning and washing, control of enzymatic and non-enzymatic changes.	6
4.	Natural sources of antioxidants for health defence, transportation, sorting, grading, peeling, sampling and size reduction, packaging, labelling; handling methods for fresh fruits, vegetables and flowers.	6
5.	Fundamental principles for food processing in organic farming, acceptable processing techniques, use of preservatives, processing aids, flavouring agents and nutrient supplement in organic food and feed processing.	8
6 & 7	Fundamental principles of food standards, HACCP system, US and European and other countries. Export/ Import standards for different crops, MRLs, sources of contamination, assessment and management of residues and toxins in food, critical control points, heavy metals and pesticide residue analysis, analytical methods and tools. Interpretation of residue analysis reports, analysis protocols and GMO report analysis.	8
8	Characteristics of packaging materials for organic food, packaging	5

	requirements for fresh organic food for local and international markets, labelling requirements for fresh and processed organic food for local and international markets, labelling requirements and management integrity.	
9.	Characteristics of packaging materials for organic food, packaging requirements for processed organic food for local and international markets, labelling requirements for fresh and processed organic food for local and international markets, labelling requirements and management integrity.	5
	Total	50

Practical

Lecture	Topic	Weightage (%)
1.	Comparative study of maturity indices for harvest of organic and conventionally grown fruits, vegetables, spices and plantation crops: Determination of physiological loss in weight and respiration rate in fruits and vegetables.	6
2.	Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/ vegetables.	6
3.	Protective skin coating with organic wax emulsion to extend the shelf life of fruits and vegetables.	6
4.	Study of effect of precooling on shelf-life and quality of fresh fruits, vegetables and flowers.	6
5	Study of packages-bulk and consumer packs for different fruits, vegetables, flowers and spices.	6
6	Study of construction and working of zero energy cool chamber. Study of storage behaviour of different fruits and vegetables in zero energy cool chamber.	7
7	Preparation and preservation of fruit-based beverages and blended products from fruits and vegetables.	5
8	HACCP analysis, residue analysis in organic products. Visit to packaging centres, local markets, cooperative organisations, super markets dealing with marketing of organic perishables.	8
	Total	50

Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Plant health will be taken care of for optimization of higher crop yield due to organic farming

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers
- *Analytical producers in soil science and Agricultural Chemistry* : by Sudharmai devi CR, Agrotech Publications.

I. Course Title	**Farming Systems Concepts and Practices for Organic Farming**
II. Course Code	OF 506
III. Credit Hours	2+1
IV. Aim of the course	To provide knowledge on practices of organic farming

Theory

UNIT	Proposed Course Content
I	Introduction Farming systems: Definition, importance, classification and scope, Classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises, Concept of sustainability in farming systems, role of integrated farming systems in agriculture, approaches
II	Agro-ecology Concepts and practices, Agro-ecology and the design of Sustainable Agro-ecosystems, Ecological processes to optimize in agro-ecosystems, Sustainable Agriculture: Basic Definitions and Concepts, Alternative Sustainable Farming Systems, Low external input sustainable agriculture
III	Enterprises selection and Integration Natural Farming Systems, Intentional Integrated Farming Systems, Pre-dominant farming systems in various regions, Eco-physiological approaches component selection and integration, Complementary and competitive interaction, Primary, Secondary, Complimentary and Supplementary enterprises for organic farming, livestock based systems, vertical farming, Principles and Practices of organic livestock production, Principles of organic aquaculture, Organic fruit and vegetable production practices, Models of integrated farming systems for irrigated ecosystems and rainfed ecosystems
IV	Modeling of farming systems Simulation models for intercropping, farming system design using farm design for various resource conditions, Linear programming, Multi-objective criteria decision making, Fuzzy logic analysis, Artificial Neural Network (ANN) based modeling, DSSAT, Infocrop, Cropsyst, Livesim
V	Integrated Organic Farming Systems Concepts, Principles, Strategies, Diversity plantations, Diversified cropping systems, study of various integrated organic farming systems and their efffect on socio economic status of farming families, crop rotations, soil fertility management, Selection of seeds, varieties and planting material, nutrient management, weed and pest management, integration of livestock, breeds and allied activities, *In-situ* recycling of Organic Wastes, Products and processes of composting, Component optimization, Market input chain, family employment generation, case studies, supplementary, Complimentary and substitution effects under dry-land, irrigated, wetland and hill-zone eco systems
VI	Soil-crop-livestock-human chain Bio-nutrition concepts, design of farming systems for nutrition, Household level production of food, feed, fodder, fertilizer, fuel and fibre from farming systems
VII	Secondary Agriculture Product diversification, Process diversification, processing of marketable surplus produces, packaging, branding and marketing
VIII	Contract Farming

	Farming system based cluster formation, production, processing and marketing, FPO, legal aspects of contract farming
IX	Specialized farming systems Protected cultivation, high value crops based systems, water based farming systems, region specific integrated farming systems, medicinal and aromatic herb based systems
X	Farming System diversification Concept definition aims, existing scenario of farming systems, need for diversification, methods of diversification, horizontal and vertical diversification
XI	Four P Model of organic farming system 4P (Planning, Production, Processing and Promotion) model of organic farming systems
XII	Ecological Engineering Concept, definition, aims. Principles and Practices, Ecological engineering approach of soil fertility and pest management, examples of ecological engineering in traditional farming systems, case studies

Practical

- Agro-ecosystem analysis: Field study of farming systems in the context of production flows, energy flows and pest dynamics using quantitative tools
- Farming System typology analysis and clustering of group of farmers
- Synthesis of organic farming system model for a given region using primary and secondary data
- Estimation of ecological, economic, social and sustainable livelihood indicators for a given farming system
- Design of alternative farming systems using Farm Design and other available modelling tools
- Experiential learning on different enterprises
- Documentation of farming system case studies
- Visit to IOFS models.

Teaching Schedule

Lecture	Topic	Weightage (%)
1 & 2	Farming systems: Definition, importance, classification and scope, Classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises, Concept of sustainability in farming systems, role of integrated farming systems in agriculture, approaches.	6
3.	Concepts and practices, Agro-ecology and the design of sustainable Agro-ecosystems, ecological processes to optimize in agro-ecosystems.	6
4.	Sustainable Agriculture: Basic Definitions and Concepts, Alternative Sustainable Farming Systems, Low external input sustainable agriculture.	6
5.	Natural Farming Systems, Intentional Integrated Farming Systems, Pre-dominant farming systems in various regions, Eco-physiological approaches, component selection and integration, Complementary	6

	and competitive interaction.	
6 & 7	Primary, Secondary, Complimentary, Supplementary enterprises for organic farming, livestock based systems, vertical farming, principles and practices of organic livestock production, principles of organic aquaculture, organic fruit and vegetable production practices,	6
8.	Models of integrated farming systems for irrigated ecosystems and rainfed ecosystems.	4
9.	Simulation models for intercropping, farming system design using farm design for various resource conditions, Linear programming, Multi-objective criteria decision making, Fuzzy logic analysis, Artificial Neural Network (ANN) based modeling, DSSAT, Infocrop, Cropsyst, Livesim	6
10 & 11	Integrated organic farming systems, its concepts and principles, strategies, diversity plantations, diversified cropping systems, study of various integrated organic farming systems and their effect on socio economic status of farming families, crop rotations, soil fertility management, selection of seeds, varieties and planting material, nutrient management, weed and pest management, integration of livestock, breeds and allied activities in Integrated organic farming systems.	10
12.	In-situ recycling of organic wastes, products and processes of composting, component optimization, market input chain, family employment generation, case studies, supplementary, complimentary and substitution effects under dry-land, irrigated, wetland and hill-zone eco systems in reference to integrated organic farming systems.	6
13.	Bio-nutrition concepts, design of farming systems for nutrition, household level production of food, feed, fodder, fertilizer, fuel and fibre from farming systems	6
14.	Product diversification, process diversification, processing of marketable surplus produces, packaging, branding and marketing	6
15.	Farming system based cluster formation, production, processing and marketing, FPO, legal aspects of contract farming	6
16.	Specialized farming systems viz. protected cultivation, high value crops based systems, water based farming systems, region specific integrated farming systems, medicinal and aromatic herb based systems	6
17.	Farming system diversification its concept, definition, aims, existing scenario of farming systems, need for diversification, methods of diversification, horizontal and vertical diversification.	8
18.	Study of four P Model of organic farming system i.e. 4P (Planning, Production, Processing, and Promotion) model of organic farming systems.	6
19.	Ecological engineering and its concept, definition, aims, principals and practices, ecological engineering approach of soil fertility and	6

	pest management, examples of ecological engineering in traditional farming systems, case studies.	
	Total	100

Practical

Exercise	Topic	Weightage (%)
1.	Agro-ecosystem analysis: Field study of farming systems in the context of production flows, energy flows and pest dynamics using quantitative tools	7
2.	Farming System typology analysis and clustering of group of farmers	5
3.	Synthesis of organic farming system model for a given region using primary and secondary data	6
4.	Estimation of ecological, economic, social and sustainable livelihood indicators for a given farming system	5
5.	Design of alternative farming systems using Farm Design and other available modelling tools	7
6.	Experiential learning on different enterprises	7
7.	Documentation of farming system case studies	5
8.	Visit to IOFS models.	8
	Total	50

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion Learning outcome: leadership development for an organic entrepreneur

Suggested Reading

- *Basics of Organic Farming:* by Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title	**Organic Certification, Standards and Regulations**
II. Course Code	OF 507 (Proposed Teaching Schedule Theory)
III. Credit Hours	2+1
IV. Aim of the course	To provide knowledge Organic Certification, Standards and Regulations

Theory

Unit	Proposed Course Content
I	National and international regulations on quality assurance and certification National Programme for Organic Production (NPOP), National Standards for Organic Production (NSOP), USDA NOP Programme and standards, EU Organic standards, Codex Alimentarius, Canada Organic regulation and important differences between NPOP and international standards. FSS Act 2006 for organic food, basic requirements, enforcement, standard operating procedures and verification in value chain
II	ISO systems for quality assurance (ISO 17065, ISO 17011, ISO 19011 etc) and accreditation processes What is ISO, salient features and functions of ISO, ISO systems for auditing, ISO 17065 for auditing and certification agencies, ISO 19011 Inspection protocols, ISO17011 Accreditation requirements, ISO 17025 Accreditation of quality analysis laboratories. Accreditation procedure and policies under NPOP, Essential requirements and competence for making an organic certification body, Conflict of interest management
III	Types of certification systems (NPOP and PGS), standards and procedures NPOP - A third party certification systems, Certification bodies operational policies and functions, National standards for crop production, livestock, Aquaculture, Processing and handling and other miscellaneous systems. Tracenet the online data management tool and traceability management PGS – Participatory Guarantee Systems – Evolution of PGS Systems, Guiding principles, PGS Standards, International scenario on PGS development Procedure for organic guarantee under PGS systems, PGS-India programme, operation of PGS-India programme, institutional structure, PGS-India Data management platform, management of traceability.
IV	On-field management of standard compliance and documentation Issues for implementation of standards on field such as conversion period, contamination control, fertility management, living condition requirement for livestock, management of integrity in processing and handling, Fundamental policy for inspections, step-by-step inspection protocols, Development of inspection formats and inspection checklists. Documentation requirements such as organic system plan, field operation register, input and cultural practices record, processing record, purchase and sales records and product flow in processing.
V	Individual and grower group certification management Basic requirements for certification management by (a) Individual producer and (b) Grower/ producer groups. Applicability and types of systems covered
VI	Inspection (under NPOP) and peer review (under PGS) systems

	Fundamental principles of inspection, checklists and inspection parameters, general policy frame work NPOP – Third party inspection procedure, risk assessment, documentation and record keeping review, physical verification of facilities, fields and stables, production facilities, estimated yield/production assessment, tracking the product flow throughout the process, chain of custody. Review of inspection forms and checklists and certification decisions. PGS-India – Peer review principles, making of peer review committees and peer review checklists, analysis of peer review checklists and certification decisions. Submission of summary sheets to Regional councils and assessment and endorsement of certification decisions.
VII	Certification of crop, livestock, aquaculture and other systems Standards, their implementation in production systems, measures for contamination control, integrity management, sanitation and hygiene, input evaluation procedures, development of process tracking checklist
VIII	Certification of processing, handling, trading and management of traceability Standards, their implementation in production/ processing and handling systems, measures for contamination control, integrity management, sanitation and hygiene, packaging and labelling, development of process tracking checklists
IX	Internal control system management in large farmer groups under NPOP Large farmer groups, essential requirements, internal control systems, development of ICS operating manual, management of ICS, internal inspections, risk assessment, assessment of internal inspections and certification decisions, additional documentation for groups, produce/ output management and sale record management
X	PGS Group development and PGS certification management Essential requirements for local groups, development of local group operating manuals, requirements of group meetings and trainings, decision making by farmers, operational policies for Regional Councils, developing operating manual for Regional councils, assessment of summary sheets and decisions of local groups, procedure for decision endorsement and certification granting

Practical

- Documentation of certification procedures, acquaintance with record keeping, handling, labeling and preparation of farmers IDs for developing ICS.
- Visit to certification bodies, certified farms, certified processing and handling operations
- Development of organic system plan for specific production system
- Development of inspection format and checklists for specific production system
- Development of operating procedures on specific aspects
- Risk assessment on organic farms and possible mitigating measures
- Running of audit trails in certified operations
- Mock inspections of different production systems
- Exercise on inspection report/ peer evaluation checklist review and certification decision
- Methods of yield assessment

Teaching Schedule

Lecture	Topic	Weightage (%)
1 and 2	National Programme for Organic Production (NPOP), National Standards for Organic Production (NSOP), USDA NOP Programme and standards, EU Organic standards, Codex Alimentarius, Canada Organic regulation and important differences between NPOP and international standards.	4
3	FSS Act 2006 for organic food, basic requirements, enforcement, standard operating procedures and verification in value chain	4
4 and 5	What is ISO, salient features and functions of ISO, ISO systems for auditing, ISO 17065 for auditing and certification agencies, ISO 19011 Inspection protocols, ISO17011 Accreditation requirements, ISO 17025 Accreditation of quality analysis laboratories.	8
6	Accreditation procedure and policies under NPOP, Essential requirements and competence for making an organic certification body, Conflict of interest management	4
7	A third party certification systems, Certification bodies operational policies and functions	4
8 and 9	National standards for crop production, livestock, Aquaculture, Processing and handling and other miscellaneous systems. Trace net the online data management tool and traceability management	6
10 and 11	Participatory Guarantee Systems – Evolution of PGS Systems, Guiding principles, PGS Standards, International scenario on PGS development Procedure for organic guarantee under PGS systems	6
12	PGS-India programme, operation of PGS-India programme, institutional structure, PGS-India Data management platform, management of traceability.	6
13	Issues for implementation of standards on field such as conversion period, contamination control, fertility management, living condition requirement for livestock, management of integrity in processing and handling,	**6**
14	Documentation requirements such as organic system plan, field operation register, input and cultural practices record, processing record, purchase and sales records and product flow in processing.	6
15	Basic requirements for certification management by (a) Individual producer and (b) Grower/ producer groups. Applicability and types of systems covered	4
16	Fundamental principles of inspection, checklists and inspection parameters, general policy frame work.	2
17,18,19	NPOP – Third party inspection procedure, risk assessment, documentation and record keeping review, physical verification of facilities, fields and stables, Production facilities, estimated yield/production assessment,	8

	tracking the product flow throughout the process, chain of custody. Review of inspection forms and checklists and certification decisions.	
20	PGS-India – Peer review principles, making of peer review committees and peer review checklists, analysis of peer review checklists and certification decisions.	4
21	Submission of summary sheets to Regional councils and assessment and endorsement of certification decisions.	4
22	Standards, their implementation in production systems, measures for contamination control, integrity management, sanitation and hygiene, input evaluation procedures, development of process tracking checklist	4
23	Standards, their implementation in production/ processing and handling systems, measures for contamination control, integrity management, sanitation and hygiene, packaging and labelling, development of process tracking checklists	4
24,25,26	Large farmer groups, essential requirements, internal control systems, development of ICS operating manual, management of ICS, internal inspections, risk assessment, assessment of internal inspections and certification decisions, additional documentation for groups, produce/ output management and sale record management	8
27 and 28	Essential requirements for local groups, development of local group operating manuals, requirements of group meetings and trainings, decision making by farmers, operational policies for Regional Councils, developing operating manual for Regional councils, assessment of summary sheets and decisions of local groups	8
	Total	100

Practical

Exercise	**Topic**	**Weightage (%)**
1	Documentation of certification procedures, acquaintance with record keeping, handling, labeling and preparation of farmers IDs for developing ICS.	7
2	Visit to certification bodies, certified farms, certified processing and handling operations	5
3	Development of organic system plan for specific production system	5
4	Development of inspection format and checklists for specific production system	5
5	Development of operating procedures on specific aspects	5
6	Risk assessment on organic farms and possible mitigating measures	5

7	Running of audit trails in certified operations	5
8	Mock inspections of different production systems	5
9	Exercise on inspection report/ peer evaluation checklist review and certification decision	5
10	Methods of yield assessment	3
	Total	50

Learning outcome

Educating to become a real organic grower

Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B.Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title	**Value Chain Management**
II. Course Code	OF 508
III. Credit Hours	2+2
IV. Aim of the course	To provide knowledge on value chain for optimization of crop yield due to organic farming

Theory

UNIT	Proposed Course Content
I	Introduction What is value chain? Defining value chain and its finance (Internal value chain finance, External value chain finance, Interest around value chain finance in agriculture, interest in value chain finance in agriculture); Overview of value chain management.
II	Understanding agricultural value chain finance Context, the concept of agricultural value chain finance, Agricultural value chain finance as an approach, Enabling environment (standards and certification, regulation and enforcement, macro-economic and social context), and Value chains and diversified livelihoods.
III	Value chain business models Producer-driven value chain models, Buyer-driven value chain models, Facilitated value chain models, and Integrated value chain models. B2B and B2C market chain. Case Study On commercial village approach.
IV	Agricultural value chain finance instruments Product overview, Product financing (trader credit, input supplier credit, marketing company credit, lead firm financing), Receivables financing (Trade receivables finance, factoring and forfeiting), Physical asset collateralization (warehouse receipts, repurchase agreements, financial lease), Risk mitigation products (crop/ weather insurance, forward contracting, futures), Financial enhancements (securitization, loan guarantees, joint ventures). Case Study 2. Producer-driven financing of farm inputs: informal inventory credit; Case Study 3. Integrated financial instruments and value chain services.
V	Innovations Value chain innovations, Financial innovations, Technological innovations (management systems, networks and exchanges, mobile phones and mobile banking), Infrastructural innovations, Policy and public sector innovations. Case Study 4. Technological innovations; Case Study 5. Avenues for sustainable agricultural development.
VI	Leadership Approaches for Successful Food Value Chains Values-Based Leadership, Values-Based Leadership in Practice, Leadership in succession.

Practicals

- Collection, aggregation and value addition
- Maintain quality and integrity of the product - practices and procedures, monitoring practices and procedures followed, record keeping systems, management practices and

separation measures, handling and processing of organic products

- Pest control - Treatments with pest regulating agents – permitted [physical barriers, sound, ultra-sound, light and UV-light, traps (incl. pheromone traps and static bait traps), temperature control, controlled atmosphere and diatomaceous earth] and prohibited
- Ingredients - approved and prohibited ingredients (microorganisms, minerals, gases)
- Processing methods - permitted and prohibited mechanical, physical and biological
- Packaging - permissible biodegradable, recyclable, reusable systems and eco-friendly packaging
- Labeling - labeling requirements for agricultural commodities and processed food
- Storage and Transport - permitted conditions of storage to maintain productintegrity
- Food additives including carriers for use in production of processed organic food
- Processing aids and other products for use for processing of ingredients of agricultural origin from organic production flavouring agents, Preparations of Micro-organisms, Ingredients
- Approved products for packaging of organic foodstuffs incl. Permissible packaging material for aquaculture

Teaching Schedule

Lecture	Topic	Weightage (%)
1 and 2	What is value chain? Defining value chain and its finance. Overview of value chain management.	4
3 and 4	Value chain finance- Internal value chain finance, External value chain finance, Interest around value chain finance in agriculture, interest in value chain finance in agriculture	8
5,6 and 7	Concept of agricultural value chain finance, Agricultural value chain finance as an approach, Enabling environment -standards and certification, regulation and enforcement, macro-economic and social context and Value chains and diversified livelihoods.	12
8 and 9	Producer-driven value chain models, Buyer-driven value chain models, Facilitated value chain models, and Integrated value chain models.	12
10	B2B and B2C market chain. Case Study On commercial village approach.	8
11	Product overview, Product financing -trader credit, input supplier credit, marketing company credit, lead firm financing	8

12	Receivables financing -Trade receivables finance, factoring and forfeiting	8
13	Physical asset collateralization -warehouse receipts, repurchase agreements, financial lease	4
14	Risk mitigation products -crop/ weather insurance, forward contracting, futures	4
15	Financial enhancements -securitization, loan guarantees, joint ventures	4
16	Case Study 2. Producer-driven financing of farm inputs: informal inventory credit	4
17	Case Study 3. Integrated financial instruments and value chain services.	8
18 and 19	Value chain innovations, Financial innovations, Technological innovations - management systems, networks and exchanges, mobile phones and mobile banking	4
20	Infrastructural innovations, Policy and public sector innovations.	4
21	Case Study 4. Technological innovations;	4
22	Case Study 5. Avenues for sustainable agricultural development.	4
	Total	100

Practical

Exercise	Topic	Weightage (%)
1	Collection, aggregation and value addition	5
2	Maintain quality and integrity of the product - practices and procedures, monitoring practices and procedures followed, record keeping systems, management practices and separation measures, handling and processing of organic products	5
3	Pest control - Treatments with pest regulating agents – permitted [physical barriers, sound, ultra-sound, light and UV-light, traps (incl. pheromone traps and static bait traps), temperature control, controlled atmosphere and diatomaceous earth] and prohibited	5
4	Ingredients - approved and prohibited ingredients (microorganisms, minerals, gases)	5
5	Processing methods - permitted and prohibited mechanical, physical and biological	5
6	Packaging - permissible biodegradable, recyclable, reusable systems and eco-friendly packaging	5
7	Labeling - labeling requirements for agricultural commodities and processed food	5
8	Storage and Transport - permitted conditions of storage to maintain productintegrity	5
9	Food additives including carriers for use in production of processed organic food	5
10	Processing aids and other products for use for processing of ingredients of agricultural origin from organic production flavouring agents,	3

	Preparations of Micro-organisms, Ingredients	
11	Approved products for packaging of organic foodstuffs incl. Permissible packaging material for aquaculture	2
	Total	**50**

Teaching methods/activities Classroom teaching with AV aids, group discussion, assignment and class discussion
Outcome High value in organic products

Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition.
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers.
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title	**Marketing**
II. Course Code	OF 509
III. Credit Hours	2+0
IV. Aim of the course	To provide knowledge on marketing of organic produce for economic profit of the grower

Theory

UNIT	Proposed Course Content
I	Marketing and its types. Facets of marketing, Facilitating functions of a market, What's special about agricultural markets? Market integration, market efficiency. Pricing policy and Role of prices.
II	Basics of Supply and Demand. Demand, Aggregate demand, Supply and Aggregate supply.
III	Food Marketing Channel Understanding the food marketing channel, Scenario Analysis.
IV	Market intelligence Marketresearch, Production cost assessment, Projecting Revenues, Accounting, Market Selection.
VI	Organic Food Distribution System Domestic market structures, and classification framework, urban organic retail models, Organic specialty stores, markets and health food stores. Direct marketing and Community Supported Agriculture.
VII	Market Potential for Organic Foods Consumer preferences and perceptions (organic sensitivity, building awareness on organic foods and consumer needs, shopping Behaviour, factors influencing purchases of new foods), general trade and organized retail.
VIII	e-Marketing and e-Consumer Perceptions and Behaviour Why organic food, source and perception of organic foods, uses of organic food, resistance to use organic products, source of awareness, organic food-is it a fad?, On-line retail and home delivery services, role of advertising and choice of media, understanding the role of quality in marketing, perception of health benefits and assurance/certification.
IX	Consumer purchase Behaviour and habits Shopping Behaviour, role of influencer in decision making, concern over adulteration, chemicals, loss of nutrients and vitamins during processing and manufacturing and its impact on marketing and sale. Accessibility of organic foods, premiums and willingness to pay premiums, role of retailer, consumer surplus, producer surplus. Efficient supply chains and retail channels, sustainability of supply chain.
X	Challenges and success stories Programmes of GOI for promotion of orgnic farming in India. Success stories in organic marketing, organizational models, their advantages, challenges, limitations and legal context. problems in marketing of organic products.

Teaching Schedule

Lecture	Topic	Weightage (%)
1	Facets of marketing, Facilitating functions of a market, What's special about agricultural markets?	4
2	Market integration, market efficiency.	4
3	Pricing policy and Role of prices.	2
4	Demand, Aggregate demand.	4
5	Supply and Aggregate supply	4
6	Understanding the food marketing channel, Scenario Analysis.	2
7	Market research, Production cost assessment	8
8	Projecting Revenues, Accounting, Market Selection.	4
9	Organic production and domestic market size	4
10	Institutional context and regulations - NPOP, NSOP	2
11	Institutional context and regulations - APGMC Act, PGS,	4
12	Institutional context and regulations- FSSAI, Jaivik Bharat	2
13	Domestic market structures, and classification framework	4
14	Urban organic retail models, Organic specialty stores, markets and health food stores	4
15	Direct marketing and Community Supported Agriculture.	2
16	Consumer preferences and perceptions -organic sensitivity, building awareness on organic foods and consumer needs, shopping Behaviour	4
17	factors influencing purchases of new foods	2
18	General trade and organized retail.	2
19	Why organic food, source and perception of organic foods	2
20	uses of organic food,source of awareness, organic food-is it a fad?	4
21	resistance to use organic products, On-line retail and home delivery services	2
22	role of advertising and choice of media, understanding the role of quality in marketing	2
23	perception of health benefits and assurance/certification Shopping Behaviour	2
24	role of influencer in decision making, concern over adulteration chemicals, loss of nutrients and vitamins during processing	4
25	manufacturing and its impact on marketing and sale	2
26	Accessibility of organic foods, premiums and willingness to pay premiums,	4
27	role of retailer, consumer surplus, producer surplus.	2
28	Efficient supply chains and retail channels, sustainability of supply chain	4
29	Programmes of GOI for promotion of organic farming in India	2
30	Success stories in organic marketing	2
31	organizational models, their advantages, challenges, limitations and legal context.	4

32	Problems in marketing of organic products.	2
	Total	100

Teaching methods/activities Classroom teaching with AV aids, group discussion, assignment and class discussion
Learning outcome Basic knowledge on marketing to get higher prices in organic produces.
Suggested Reading • *Basics of Organic Farming:* Mamta Bansal. Kindle Edition • *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers. • *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers • *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title	**Research Methodology and Biostatistics**
II. Course Code	OF 510
III.Credit Hours	2 + 1
IV. Aim of the course	To provide knowledge on Research metyhodology for organic produce for bio stastical analysis and data generation

UNIT	Proposed Course Content
I	**Experimental techniques:** Research design, sampling, data collection, On-station experimentation, On-Farm experimentation, tabulation, Statistical tools and analysis techniques for interpretation of data.
II	**Geo-referenced characterization:** Questionnaire design principles, Questionnaire design for consumers of organic products, Questionnaire design for farmers and producers of organic products, Questionnaire design for processors/ traders/ exporters, Geo-spatial analysis and mapping of organic farms/ producers/ traders/ consumers.
III	**Meta data analysis:** Concepts, statistical methods, clustering research results, Holism, Positivism, Objectivism, Reductionism, Constructivism, Subjectivism, data source, Variable coding and analysis, interpretation.
IV	**Niche area and crops for organic farming:** Parameters for niche area and crop, Different scales of niche area, Tools and steps in Niche area and crop identification, **Parameterization and classification based on macro, regional and micro level.**
V	**Climate resilience of organic farming:** Methodology for identification of climate resilient production systems, GHG's estimation using IPCC, GHG's measurement using instrumentation, Global Warming Potential, Energy & Carbon budgeting.
VI	**Breeding for organic production system:** Conventional breeding strategies for organic production, participatory plant breeding, Marker aided selection, Stability analysis, Molecular characterization of indigenous organic inputs, Bio-chemical and molecular signature of organic produces.
VII	**Commercial Project Formulation on Organic Farming:** Internal rate of return, Pay Back period, B: C ratio, Debit service covarage ratio. Net Present Value, Model project formulation for organic farming, Impact analysis tools and methods.
VIII	**Farming System model development: Synthesis of IOFS models using primary and secondary data, classification, validation of farming systems.**
IX	**Notations in statistics:** Basics of statistical notation, Algebric rules, designing a variable, standard notation for statistics.
X	**Descriptive statistics:** Measures of central tendency, measures of variability, relative scores, measures of relationship, skewness, kurtosis.
XI	**Introduction to statistical inference and testing of hypothesis:** Statistical model, point estimation, confidence intervals, hypothesis testing, t-test, non-parametric alternative sign test.

Practical

- Synthesis of farming system model
- Estimation of GHG emission from IPCC tool
- Meta data analysis using published papers
- Identification and niche area and crops for a district or block
- Identification of Climate resilient production system using long term meteorological data

- Commercial project formulation
- Bankable project preparation
- Geo-spatial analysis using GIS platform
- Carbon and energy budgeting of an organic farm

Teaching Schedule

SN	Topic	No. of Lecture (s)
1.	Experimental techniques: Research design, sampling, data collection, On-station experimentation, On-Farm experimentation, tabulation, Statistical tools and analysis techniques for interpretation of data.	03
2.	Geo-referenced characterization: Questionnaire design principles, Questionnaire design for consumers of organic products, Questionnaire design for farmers and producers of organic products, Questionnaire design for processors/ traders/ exporters, Geo-spatial analysis and mapping of organic farms/ producers/ traders/ consumers.	04
3.	Meta data analysis: Concepts, statistical methods, clustering research results, Holism, Positivism, Objectivism, Reductionism, Constructivism, Subjectivism, data source, Variable coding and analysis, interpretation.	04
4.	Niche area and crops for organic farming: Parameters for niche area and crop, Different scales of niche area, Tools and steps in Niche area and crop identification, Parameterization and classification based on macro, regional and micro level.	03
5.	Climate resilience of organic farming: Methodology for identification of climate resilient production systems, GHG's estimation using IPCC, GHG's measurement using instrumentation, Global Warming Potential, Energy & Carbon budgeting.	03
6.	Breeding for organic production system: Conventional breeding strategies for organic production, participatory plant breeding, Marker aided selection, Stability analysis, Molecular characterization of indigenous organic inputs, Bio-chemical and molecular signature of organic produces.	03
7.	Commercial Project Formulation on Organic Farming: Internal rate of return, Pay Back period, B: C ratio, Debit service covarage ratio. Net Present Value, Model project formulation for organic farming, Impact analysis tools and methods.	03
8.	Farming System model development: Synthesis of IOFS models using primary and secondary data, classification, validation of farming systems.	02
9.	Notations in statistics: Basics of statistical notation, Algebric rules, designing a variable, standard notation for statistics.	02
10.	Descriptive statistics: Measures of central tendency, measures of variability, relative scores, measures of relationship, skewness, kurtosis.	02
11.	Introduction to statistical inference and testing of hypothesis: Statistical model, point estimation, confidence intervals, hypothesis testing, t-test, non-parametric alternative sign test.	03
	Total	32

Practicals

Sr. No.	Topic	No. of Practical (s)
1	Synthesis of farming system model	1
2	Estimation of GHG emission from IPCC tool	2
3	Meta data analysis using published papers	2
4	Identification and niche area and crops for a district or block	2
5	Identification of Climate resilient production system using long term meteorological data	2
6	Commercial project formulation	1
7	Bankable project preparation	1
8	Geo-spatial analysis using GIS platform	2
9	Carbon and energy budgeting of an organic farm	2
	Total	15

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

Learning outcome

Basic knowledge on marketing to get higher prices in organic produces.

Suggested Reading

- *Basics of Organic Farming:* Mamta Bansal. Kindle Edition
- *The Complete book of Organic farming and products of organic compost:* NPCS Board of consultants and Engineers.
- *ABC of Organic Farming:* Amitava Rakshit and H.B. Singh. Jain Brothers
- *Principles of Organic Farming:* S.R. Reddy. Kalyani Publisher.

I. Course Title	**Organic Input Management and Production Technologies**
II. Course Code	OF 511
III. Credit Hours	2 + 1
IV. Aim of the course	To provide knowledge on various organic inputs, their production technologies, quality control and commercialization aspects

Theory

UNIT	Proposed Course Content
I	**Introduction** Need for on-farm and off-farm (external) organic inputs, types of organic inputs allowed under organic farming, regulatory scenarios and standards. Status of organic and biological input industry in the country.
II	**On-farm inputs soil fertility and nutrient management** Types of on-farm inputs for soil fertility and nutrient management, their need assessment under specific cropping systems *vis-à-vis* soil test reports, methodologies for recycling of on-farm biomass and crop residue, innovative traditional inputs such as jivamrit, beejamrit, panchgavya, amrutpani, etc. their microbial profiling and nutrient mobilization potential and standardized production methods, Oil cakes and their applications.
III	**On-farm inputs, plant health management and pest control** Types of plant protection inputs and intervention approaches, use of biological and ecological approaches, preventive practices, Types of plants used in plant protection and their biological characterization for pest control, basic methodologies for active ingredient extraction and on-farm formulations. dashparni ark and use of trap crops.
IV	**Composts and their value added products** Types of composts, their characters, nutrient potential, composting methodologies (aerobic, anaerobic, NADEP, *etc*), value added composts, quality control parameters, commercial production methodologies for city waste compost, Phosphate Rich Organic manure (PROM), bio-organic manure, technologies for product formulations such as enrichment and granulations, *etc.*
V	**Biofertilizers** Types of biofertilizers, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants.
VI	**Microbial Biopesticides** Types of biopesticides and Bio-herbicide standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier based inoculants, liquid inoculants and lyophilized inoculants. Types of polyhedrosis and granulosis viruses and their production methodologies.
VII	**Mass rearing of beneficial insects** Introduction to beneficial insects such as pest predators and parasites, classification and identification, mass rearing technologies including rearing of host insects, Production of egg cards of beneficial insects and their release in the field.

VIII	**Botanical pesticides and other non-chemical pest protectants** Type of non-chemical plant protection options, importance of soaps and oils, important plants having pesticidal properties, plant parts having pesticidal active ingredient and their extraction methodologies, product formulation and stabilization for increased shelf life, field assessment of efficacy. Regulatory scenario and quality parameters.

Practical

- Getting familiarized with on-farm soil fertility management inputs (such as beejamrit, jivamrit, panchgavyaetc), ingredients needed and production methodology. Preparation and quality assessment
- Application of such inputs in small plots on selected crops and observation on growth
- Production of different composts including vermicompost
- Quality analysis of composts for nutrients and heavy metals
- Biofertilizer organisms, their laboratory characterization, sub-culturing and mother culture development
- Fermentation technology demonstration, production of bacterial broth in pilot scale fermenters
- Biofertilizer product formulations and quality analysis methods
- Study of biopesticide organisms, laboratory culturing, mass cultivation using solid state fermentation, liquid fermentation and spore harvesting methods and product formulations
- Visit to beneficial insect rearing laboratory and handling of insects including demonstration on tricho-cards production
- Extraction of neem seed kernel extracts and neem oil. Production of botanical extracts and product formulation using emulsifiers
- Study effect of various botanical extracts on insect pests
- Preparation of Bordeaux mixtures and copper fungicides

Teaching Schedule

SN	Topic	No. of Lecture (s)
1.	Need for on-farm and off-farm (external) organic inputs, types of organic inputs allowed under organic farming, regulatory scenarios and standards.	03
2.	Status of organic and biological input industry in the country.	01
3.	Types of on-farm inputs for soil fertility and nutrient management, their need assessment under specific cropping systems vis-à-vis soil test reports,	02
4.	Methodologies for recycling of on-farm biomass and crop residue,	02
5.	Innovative traditional inputs such as jivamrit, beejamrit, panchgavya, amrutpani, etc. their microbial profiling and nutrient mobilization potential and standardized production methods, Oil cakes and their applications.	03
6.	Types of plant protection inputs and intervention approaches,	02
7.	Use of biological and ecological approaches, preventive practices,	02
8.	Types of plants used in plant protection and their biological characterization for pest control,	01
9.	Basic methodologies for active ingredient extraction and on-farm formulations. dashparni ark and use of trap crops.	02

10.	Types of composts, their characters, nutrient potential, composting methodologies (aerobic, anaerobic, NADEP, etc),	02
11.	Value added composts, quality control parameters, commercial production methodologies for city waste compost, Phosphate Rich Organic manure (PROM), bio-organic manure, technologies for product formulations such as enrichment and granulations, etc.	02
12	Types of biofertilizers, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants.	03
13	Types of biopesticides and Bio-herbicide standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier based inoculants, liquid inoculants and lyophilized inoculants. Types of polyhedrosis and granulosis viruses and their production methodologies.	03
14	Introduction to beneficial insects such as pest predators and parasites, classification and identification, mass rearing technologies including rearing of host insects, Production of egg cards of beneficial insects and their release in the field.	03
15	Type of non-chemical plant protection options, importance of soaps and oils, important plants having pesticidal properties, plant parts having pesticidal active ingredient and their extraction methodologies, product formulation and stabilization for increased shelf life, field assessment of efficacy. Regulatory scenario and quality parameters.	03
	Total	34

Practicals

Sr. No.	**Topic**	**No. of Practical (s)**
1	Getting familiarized with on-farm soil fertility management inputs (such as beejamrit, jivamrit, panchgavya etc), ingredients needed and production methodology. Preparation and quality assessment	2
2	Application of such inputs in small plots on selected crops and observation on growth	1
3	Production of different composts including vermicompost	2
4	Quality analysis of composts for nutrients and heavy metals	2
5	Biofertilizer organisms, their laboratory characterization, sub-culturing and mother culture development	2
6	Fermentation technology demonstration, production of bacterial broth in pilot scale fermenters	2
7	Biofertilizer product formulations and quality analysis methods	2

8	Study of biopesticide organisms, laboratory culturing, mass cultivation using solid state fermentation, liquid fermentation and spore harvesting methods and product formulations	2
9	Visit to beneficial insect rearing laboratory and handling of insects including demonstration on tricho-cards production	1
10	Extraction of neem seed kernel extracts and neem oil. Production of botanical extracts and product formulation using emulsifiers	2
11	Study effect of various botanical extracts on insect pests	1
12	Preparation of Bordeaux mixtures and copper fungicides	1
	Total	20

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion. Practical in the laboratory, visit to production sites and demonstration of production protocols through industry visits, practical on analysis protocols

Learning outcome

Basic knowledge on marketing to get higher prices in organic produces.

Suggested Reading

- *The Complete Technology Book on Vermiculture and Vermicompost*, NPCS Board of consultants and Engineers, Asia Pacific Business Press
- *Training material on Composting and Vermicomposting*, Published by Ecosan Services Foundation
- *Biofertilizers and Biopesticides*, A, Channabasava and H.C. Lakshman
- *Handbook of Biofertilizers and Biopesticides*, by AM Deshmukh, RM Khobrgade and PP Dixit
- *Mass Production of Beneficial Organisms*, by J. Morales-Ramos, M. Guadalupe and DS Ilan, Academic Press, 2013.

A list of international and national reputed Journals

Sr. No	Name of international and national reputed journals	NAAS Score
1	Advances in Agronomy	11.02
2	Agricultural Water Management	8.45
3	Agriculture, Ecosystems & Environment (Netherlands)	9.20
4	Agroforestry Systems	7.24
5	Agronomy Journal (Journal of American Society of Agronomy)	7.54
6	Agronomy for Sustainable Development (Agronomie)	8.84
7	Applied Ecology and Environmental Research	6.46
8	Crop Science	7.48
9	Crop and Pasture Science (Australian Journal of Agricultural Research)	7.28
10	European Journal of Agronomy	8.92
11	Field Crops Research	8.61
12	Indian Journal of Agricultural Sciences	6.00
13	Indian Journal of Agronomy	5.00
14	International Journal of Agricultural Sustainability	7.75
15	International Journal of Water Resources Development	6.90
16	Irrigation Science	8.84
17	Journal of Agricultural Science, Cambridge	8.89
18	Journal of Agronomy and Crop Science	8.62
19	Journal of Crop and Weed	3.59
20	Journal of Farming Systems Research & Development	3.41
21	Journal of Soil and Water Conservation	7.81
22	Journal of Soils and Crops	3.77
23	Journal of Water Resources, Planning and Management	7.76
24	Resources, Conservation and Recycling	8.69
25	Research on Crops	6.00
26	Weed Research	8.02
27	Weed Science	7.68
28	Indian Journal of Weed Science	3.94
29	Organic Agriculture	--
30	Organic Farming Journal	--
31	Journal of Plant Biology & Agriculture Sciences	--
32	Journal of Organic Agriculture & Environment	--
33	Indian Journal of Organic Farming	--
34	Journal of Sustainable Agriculture & Environment	--
35	Organic Farming Nature Journal	--
36	Journal of Integrative Agriculture	--