PG Degree Programme Syllabus as per BSMA, ICAR
M.Sc. (Agri.) Agronomy

M.S. Swaminathan School of Agriculture

Centurion University of Technology and Management

Alluri Nagar, P.O. - R Sitapur, Via- Uppalada, Paralakhemundi

Dist: Gajapati – 761211

Odisha, India

2025

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Preamble

Agronomy is a discipline which deals with various processes such as cultivation, inter-culture, 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, feed, fuels and fibre for growing population in world. Agronomist today is involved with many issues including producing food, creating healthier food, managing environmental impacts, creating energy from plants and after all food and nutritional security. Research activities in Agronomy focus on system analysis and simulation modeling of environmental and management impacts on agricultural production which 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 tackling field problems and management of land. The existing M.Sc. (Agri.) 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 the course curriculum, M. Sc. (Agri.) Agronomy was restructured to equip students to tackle emerging issues by inclusion of one new course on ―Conservation agriculture‖. It was proposed by some members to include new courses like Experimental technique in Agronomy. 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 many universities. Hence these courses are merged and thereby 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.

Contents

Framework of the courses

The following nomenclature and Credit Hrs. need to be followed while providing the syllabus for all the disciplines

Courses	M.Sc. (Agri.) Credits
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
Thesis	30
Total	70

M.Sc. (Agri.) Agronomy

AGRO 0550	Master's Seminar	1+0	-
AGRO 0560	Master's Research	30	-
Minor Courses			
SOIL 0511	Management of Problem Soils and Waters	2+1	22
SOIL 0505	Soil Erosion and Conservation	2+1	23
PGPP 0501	Principles of Plant Physiology I: Plant Water Relations and Mineral Nutrition	2+1	25
PGPP 0505	Hormonal Regulation of Plant Growth and Development	2+1	28
PGPP 0507	Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modeling	2+0	31
Supporting Courses			
STAT 0502	Statistical Methods for Applied Sciences	3+1	34
STAT 0511	Experimental Designs	2+1	35
STAT 0512	Basic Sampling Techniques	2+1	37
STAT 0522	Data Analysis Using Statistical Packages	2+1	38
Common Courses			
PGSS 0501	Library and Information Services	0+1	40
PGSS 0502	Technical Writing and Communication Skills	0+1	40
PGSS 0503	Intellectual Property and its Management in Agriculture	1+0	41
PGSS 0504	Basic Concepts in Laboratory Techniques	0+1	42
PGSS 0505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0	43

***Indicates core course which is compulsory course for M Sc.(Agri.)**

M.Sc. (Agri.) Agronomy Syllabus

MAJOR COURSES

Course Code: AGRO 0501 Credit Hours: 3+0 Course Title: Modern Concepts in Crop Production

Objectives:

1. To impart the knowledge on crop growth analysis and quantitative biological properties.
2. To teach the concepts of crop production and crop modelling
3. To provide basic knowledge on modern crop production concepts and integrated farming systems

At the end of the course the students will be able to achieve the following outcomes:
Course Outcomes:

CO1: Gain knowledge Awareness on different agro-climatic and agro-ecological regions of India.

CO2: Updated with crop growth analysis in relation to environment

CO3: Know the optimum production requirement for higher yield and crop modelling

CO4: Get knowledge on crop growth and crop response production functions

CO5: Learn on organic farming, integrated farming system and modern concepts in crop production

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

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

UNIT II

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

UNIT III

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

UNIT IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

UNIT V

Integrated farming systems, organic farming, and resource conservation technologyincluding 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, Aeroponic, Hydroponic, Robotic and terrace farming. Use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

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

Suggested Reading

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

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

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

Paroda R.S. 2003. Sustaining our Food Security. Konark Publ. Reddy SR. 2000. Principles of Crop Production. Kalyani Publ.

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

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

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: Tropics versus Temperate Environments. Advances in Agronomy 42: 85-197. Wilsie, C.P. 1961. Crop Adaptation and Distribution. Euresia Pub., New Delhi.

Course Code: AGRO 0502 Credit hour: 2+1 Course Title: Principle and Practices of Soil Fertility and Nutrient Management

Objectives

1. **To impart knowledge on soil fertility management and different methods of its evaluation**
2. To educate students on different manures and fertilizers used in crop production
3. To enable them to understand about concepts of nutrient management.

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes

CO.1: Gain knowledge on soil fertility and productivity

CO-2: Understand the essential nutrient functions, and the nutrient deficiency symptoms in crops

CO-3: Familiarized with the process of organic manures and bio-fertilizer and their composition

CO-4: Gain information on fertilizers, their responses and efficiency in crop production

CO-5: Understand the time and methods of manures and fertilizer application

	PSO1	PSO2	PSO3

CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

Soil fertility and productivity - factors affecting; features of good soil management; problems

of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

UNIT II

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

UNIT III

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

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; methods of increasing fertilizeruse efficiency; nutrient interactions.

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 vermincompost and residue wastes in crops.

Practical

- Determination of soil pH
- Determination of soil soil EC
- Determination of soil organic C
- Determination of available N in soil
- Determination of available P in soil
- Determination of available K in soil Determination of available S in soil
- Determination of total N in soil
- Determination of total N in plant
- Determination of total P in plant

- Determination of total K in plant
- Determination of total S in plant
- Computation of optimum and economic yield

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

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.

Course Code: AGRO 0503 Credit Hours: 2+1 Course Title: Principles and Practices of Weed Management

Objectives

1. To comprehend weed biology, ecology and classification 2. To master knowledge on herbicide application techniques.

3. To promote sustainable weed management strategies.

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes

CO1: Attain a comprehensive understanding of weed biology, ecology, and classification.

CO2: Gain herbicide application proficiency.

CO3: Develop competence in implementing sustainable weed management strategies.

CO4: Expertise in herbicide science based on their classification, chemical properties, physiological effects, and selectivity.

CO5:Gain knowledge on advanced technologies in weed management.

	PSO1	PSO2	PSO3
CO1	✔		✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

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

UNIT II

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

UNIT III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio- agents, and allelochemicals; movement 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 aeroplanes, organic etc., cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops
- Preparation of a weed herbarium
- Weed survey in crops and cropping systems
- Crop-weed competition studies, Weed indices calculation and interpretation with data

- Calculation of herbicidal herbicide requirement
- Use of various types of spray pumps and nozzles
- Calculation of swath width, Economics of weed control
- Preparation of spray solutions of herbicides for high and low-volume sprayers,
- ,Herbicide resistance analysis in plant and soil Bioassay of herbicide resistance residues

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

Suggested Reading

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

T. K. Das. 2008. 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, U.S. 2006.

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.

Course Code: AGRO 0504 Credit Hour: 2+1 Course Title: Principles and Practices of Water Management

Objectives:

1. To gain knowledge regarding soil-water- plant relationships
2. To get expertise in efficient water use management.
3. To know the principles of water management and practices to enhance the water productivity, basic skill on water management for optimization of crop yield.

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Understand soil-water-plant relationship

CO2: Gain knowledge on crop water requirement and different types of Measurements related to this

CO3: Get familiarized with different irrigation and drainage methods

CO4: Get to know issues related to water quality and its management methods **CO5**: Able to learn water management of different field crops

	PSO1	PSO2	PSO3
CO1	✔		✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extentof 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 loses.

UNIT III

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

UNIT IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement-estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

UNIT V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

UNIT VI

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

UNIT VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

UNIT VIII

Hydroponics

UNIT IX Water management of crops under climate change scenario.

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method
- Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

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

Suggested Reading

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.

Course Code: AGRO 0505 Credit Hour: 1+1 Course Title: Conservation Agriculture

Objective:

1. To impart knowledge on conservation agriculture
2. To study the different resource management
3. To provide information on climate change and conservation agriculture

At the end of the course the students will be able to achieve the following outcomes:

Course Outcome:

CO 1: Understand the concept of conservation agriculture

CO 2: Get knowledge on resource management in conservation agriculture

CO 3: Equipped about the climate change and conservation agriculture

CO 4: Updated on conservation agriculture in rainfed areas

CO 5: Get to know economic consideration in conservation agriculture

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India

UNIT II

Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management

UNIT III

Climate change mitigation and CA, C-sequestration, soil health management, soil microbes and CA

UNIT IV

CA in agroforestry systems, rainfed /dryland regions

UNIT V

Economic considerations in CA, adoption and constraints, CA: The future of agriculture **Practical**

- Study of long-term experiments on CA
- Evaluation of soil health parameters
- Estimation of c- sequestration
- Machinery calibration for sowing different crops
- Weed seed bank estimation under CA
- Energy requirements, economic analysis of CA.

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

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

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.

Course Code: AGRO 0506 Credit Hour: 2+1 Course Title: Agronomy of Major Cereals and Pulses

Objective :

1. To impart knowledge on origin, history, area and production of major cereals and pulses
2. To make aware of varieties , adaptability , climate , soil, water and nutrient management of crops 3. To educate on handling and processing of produce

At the end of the course the students will be able to achieve the following outcomes:

Outcomes:

CO1: Gain knowledge on origin, geographical distribution, climate of major cereals and pulse crops

CO2: Understand the varieties, climate, soil, water and cultural requirement of cereals and pulse crops

CO3: Enabled to know the quality components of cereal and pulse crops

CO4: Learn handling and processing of cereals and pulses **CO5:**Gain knowledge on nutrition of cereal and pulse crops.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

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

UNIT I

Rabi cereals

UNIT II

Kharif cereals

UNIT III

Rabi pulses

UNIT IV

Kharif pulses

Practical

- Phonological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- 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)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

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

Suggested Reading

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 FieldCrops. Oxford & IBH.

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

Course Code: AGRO 0507
Credit Hour: 2+1 Course Title:
Agronomy of Oilseed, Fibre and Sugar Crops

Objective :

1. To impart knowledge on origin, history, area and production of major oilseed, fiber and sugar crop
2. To make aware of varieties , adaptability , climate , soil, water and nutrient management of oil seeds, fiber and sugar crops
3. To educate on handling and processing of produce

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Gain knowledge on origin, geographical distribution, climate of major oilseed, fibre and sugar crops. **CO2**: Understand the varieties, climate, soil, water and cultural requirement of oilseed, fibre and sugar crops

CO3: Enabled to understand the quality components of oilseed, fibre and sugar crops

CO4: Learn handling and processing of oilseed, fibre and sugar crops

CO5: Basic information on nutrition of oilseed, fibre and sugar crops

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

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

UNIT I

Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

UNIT II

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

UNIT III

Fiber crops - Cotton, Jute, Ramie and Mesta.

UNIT IV Sugar crops – Sugar-beet and Sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop Intercultural operations in different crops
- Cotton seed treatment
- Working out on growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Working out on 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)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

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

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 FieldCrops. Oxford & IBH.

Singh SS. 1998. Crop Management. Kalyani.

Course Code: AGRO 0508 Credit hour: 2+1 Course Title: Agronomy of Medicinal, Aromatic and Under Utilized Crops

Objectives :

1. To impart knowledge on origin, history, area and production of medicinal, aromatic and underutilized crops
2. To make aware of varieties , adaptability , climate , soil, water and nutrient management of crops 3. To educate on handling and processing of produce

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Gain knowledge on origin, geographical distribution, climate of medicinal, aromatic and under-utilized crops

CO2: Understand the varieties, climate, soil, water and cultural requirement of medicinal, aromatic and under-utilized crops

CO3: Understand the quality components of medicinal, aromatic and under-utilized crops

CO4: Learn handling and processing of medicinal, aromatic and under-utilized crops

CO5: Gain knowledge on nutrition of medicinal, aromatic and under-utilized crops

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

Importance of medicinal and aromatic plants in human health, national economy andrelated 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, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nuxvomica, Rosadle etc).

UNIT III

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

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.

Practical

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

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

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.

iv.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.

Course Code: AGRO 0509
Credit Hours: 2+1 Course Title:
Agronomy of Fodder and Forage Crops

Objective:

1. To impart knowledge on origin, history, area and production of fodder and forage crops.
2. To make aware of varieties, adaptability, climate, soil, water and nutrient management of fodder and forage crops.
3. To educate on handling and processing of produce

At the end of the course the students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Gain knowledge on origin, geographical distribution, climate of fodder and forage crops **CO2**: Understand the varieties, climate, soil, water and cultural requirement of fodder and forage crops

CO3: Enable to understand the quality components of fodder and forage crops

CO4: Learn handling and processing of fodder and forage crops

CO5: Overall information on nutrition of fodder and forage crops

	PSO1	PSO2	PSO3
CO1	✔		✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory
UNIT I

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

UNIT II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspectsincluding anti-quality factors of important forage crops/grasseslime, Napier grass, Panicum, Lasiuras, Cenchrus etc.

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

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

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

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.

Course Code: AGRO 0510 Credit Hours: 2+1 Course Title: Agrostology and Agro-Forestry

Objectives :

1. To acquaint with the basic terms of agrostology and agroforestry
2. To familiarize problems and management of grasslands
3. To make understand the crop production technology in agro-forestry and agrostology system

At the end of the course the students will be able to achieve the following outcomes:

Course Outcome :

CO1: Acquire information on basic concepts of agrostology

CO2: Get knowledge on pasture management

CO3: Understand the problems and management of grassland

CO4: Able to know the crop production technology in agroforestry, agrostology and silvipastoral system.

CO5: Equipped with concepts of economic viability and social acceptance of agroforestry

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔		✔

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems;

irrigation and manuring in agro- forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

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

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

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.

Course Code: AGRO 0511 Credit Hours: 2+0 Course Title: Cropping Systems and Sustainable Agriculture

Objectives:

1. To acquaint the students about prevailing cropping systems and practices to improve their productivity.
2. To understand the concept of sustainable agriculture.

3. To impart knowledge on the economic feasibility of adoption of farming system.

At the end of the course the students will be able to achieve the following outcomes:

Course outcomes:

CO1: Summarized information about prevalent cropping systems of country and its components

CO2: To understand farming systems and its components to increase economic condition of farmers

CO3: To gain knowledge regarding efficient resource management

CO4: To know the role of soil nutrients, manures, and fertilizers to attain sustainability in agriculture.

CO5: Able to know about indices and efficiency related to cropping and farming system as well as sustainable agriculture

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

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.

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

Course Code: AGRO 0512 Credit Hours: 2+1 Course Title: Dryland Farming and Watershed Management

Objectives:

1. To understand concept and characteristics of Indian rainfall pattern and dryland farming
2. To familiarize with various concepts and characteristics of dry land farming in Indian context
3. To make students know soil and crop management methods in aberrant weather conditions

At the end of the course the students will be able to achieve the following outcomes:

Course outcome:

CO1: Basic knowledge on dryland farming in Indian agriculture

CO2: Understand the rainfall characteristics and drought.

CO3: Gain knowledge regarding stress and physiology and contingent crop planning.

CO4: Know soil and crop management practices in dryland agriculture.

CO5: Get overall idea on watershed management.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔

CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET ny Penman Monteith Method
- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method Assessment of drought
- Estimation of length of growing period

- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency
- Visit to dryland research stations and watershed projects

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

Suggested Reading

Reddy T.Y.2018.Dryland Agriculture Principles &Practices, Kalyani publishers Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.

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

Gupta US. (Ed.). 1995. Production and Improvements of Crops 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.

Course Code: AGRO 0513 Credit Hours: 2+1 Course Title: Principles and Practices of Organic Farming

Objectives:

1. To understand concept of organic farming, farming system and cropping system and their relevance to current country and global scenario
2. To make familiar about nutrient, weed, disease and pest management in organic farming
3. To impart knowledge on socio-economic aspect as well as certification and accreditation procedure of organic farming.

At the end of the course the students will be able to achieve the following outcomes:

Course outcome:

CO1: Get basic knowledge on organic farming and its feasibility

CO2: Familiarized with nutrient sources used in organic farming and their management

CO3: Gain knowledge on farming systems and multiple cropping system.

CO4: Know weed and disease pest management practices in organic farming.

CO5: Enabled to know the socio-economic perspective, marketing and accreditation process of organic farming.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔		✔

Theory

UNIT I

Organic farming - concept and definition, its relevance to India and global agriculture and

future prospects; principles of organic agriculture; organics and farming standards; 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 residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermin-compost, green manures , bio-fertilizers and biogas technology.

UNIT III

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

UNIT IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

UNIT V

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

Practical

- Method of making compost by aerobic method
- .Method of making compost by anaerobic method
- Method of making vermin-compost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with Rhizobiumcultures, use of Azotobacter, Azospirillum and PSB cultures in field
- Visit to a biogas plant

- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

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

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, ParisaraprajnaParishtana, 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.

MINOR COURSES

Course Code: SOIL 0511 Credit Hours: 2+1 Course Title: Management of Problem Soils and Water

Objectives:

- To know different soil and irrigation water problems
- To determine the different characteristics of problem soils and water
- To learn different reclamation methods of problem soil to improve soil health and soil fertility

Course Outcome:

At the end of the course, the students will be able to achieve following outcomes

CO-1: Knowledge on degraded land and problem soils

CO-2: Overall idea on different reclamation and management practices for the improvement of the acid and salt affected soils.

CO-3: Estimate the quality of irrigation water

CO-4: Analyze various parameters of problematic soils, interpret results.

CO-5: Get equipped on reclamation and management practices

Theory UNIT I

Area and distribution of problem soils–acidic, saline and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

UNIT II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt affected soils-Soluble salts, ESP, pH; physical, chemical and microbiological properties.

UNIT III

Management of salt-affected soils; salt tolerance of crops mechanism and ratings; Salt stress meaning and its effect on crop Growth, monitoring of soil salinity in the field; management principles For sandy, clayey, red lateritic and dry lands oils.

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, sal t-affected and calcareous soil
- Determination of cations (Na+,K+,Ca++and Mg++)in ground water and soil samples
- Determination of anions (Cl-,SO4--,CO3--and HCO3-)in ground 🎬 Waters and soi lsamples, Lime and gypsum requirements of acid and sodic soils.

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

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Suggested Reading

Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.

Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science &Biometeorology. Utah State Univ.

USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.

Course Code: SOIL 0505 Course Credits: 2+1 Course Title: Soil Erosion and Conservation

Objective:

1. To learn the different process and factors responsible for soil erosion
2. Identify the human activities that affects the soil erosion
3. To know the methods of soil conservation

Course Outcome:

CO-1: Knowledge on causes and forms of soil erosion, classification of gullies and its control measures.

CO-2: Estimation of soil loss using soil loss equation and learning on crop management, and conservation practices.

CO-3: Distinguish various types of wind erosion along with its mitigation measures

CO-4: Overall idea about various agronomic practices of soil conservation

CO-5: Equipped with various engineering measures of soil conservation and the design of soil conversation structures

Theory

UNIT I

History, distribution, identification and description of soil erosion problems in India.

UNIT II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; Rainfall erosivity - estimation as 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 conservationin special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT V

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

- Determination of different soil erodibility indices – suspension percentage, dispersionratio, erosion ratio, clay ratio, clay/moisture equivalent ratio,
- percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Visits to a watersheds

Suggested Reading

Biswas TD & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual of Soil and Water Conservation Practices*. Oxford & IBH.

Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press. Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi. Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Course Code: PGPP 0501 Credit Hours: 2+1 Course Title: Principles of Plant Physiology I - Plant Water Relations and Mineral Nutrition

Objectives:

1. To impart knowledge in the field of water relations and mineral nutrition.
2. To acquaint knowledge on how plants obtain water and transport it.
3. To summarize various concepts related to stress physiology.

At the end of the course the students will be able to achieve the following outcomes:

Course Outcome:

CO 1: Ability to understand soil-plant water relations.

CO 2 : Gain knowledge on root functionality, transpiration, and stomatal regulation

CO 3: Understand enhancement of water use efficiency and drought tolerance strategies

CO 4 :Get knowledge on Mineral nutrition and their significance

CO 5:Learn nutrient acquisition mechanisms

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔	✔	✔
CO3	✔	✔	
CO4	✔		✔
CO5	✔		✔

Theory A. Plant Water Relations

1. Soil and Plant Water Relations
2. Water Absorption and Translocation
3. Transpiration and Evaporative Cooling
4. Water Productivity and Water Use Efficiency
5. Moisture Stress and Plant Growth **B. Mineral Nutrition**

1. Nutrient Elements and their Importance
2. Nutrient Acquisition
3. Concept of Foliar Nutrition

Block A: Plant Water Relations UNIT I

Soil and Plant Water Relations Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit II

Water Absorption and Translocation Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

UNIT III

Transpiration and Evaporative Cooling Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

UNIT IV

Water Productivity and Water Use Efficiency WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

UNIT V

Moisture Stress and Plant Growth Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block B: Mineral Nutrition UNIT I

Nutrient Elements and Their Importance Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms in plants.

UNIT II

Nutrient Acquisition Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels.

Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

UNIT III

Concept of Foliar Nutrition Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

Practical

- Standard solutions and preparation of different forms of solutions
- Studies on the basic properties of water
- Demonstration of surface tension of water and other solvents
- Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
- Determination of soil moisture content and soil water potential
- Use of soil moisture probes and soil moisture sensors

- Measurement of transpiration rate in plants; use of porometry
- Measurement of CCATD and its relevance
- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toxicity symptoms of nutrients
- Effect of water stress on plant growth and development

Suggested Reading

Vilalta JM and Forner NG. 2017. Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydricconcept Plant, Cell and Environment 40, 962–976

Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation.

Chapter 16, pp 339–354.

McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. Water Uptake and Transport in Vascular Plants. Nature Education Knowledge 4(5): 6

Hodson RC and J Acuff. 2006. Water transport in plants: anatomy and physiology. Pages 163- 183, Tested Studies for Laboratory Teaching, Volume 27 (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.

Chater CCC, Caine RS, Fleming AJ, Gray JE. 2017. Plant Physiology, 174 (2) 624-638; DOI:

10.1104/pp.17.00183

Dietrich P, Sanders D, Hedrich R. 2001. The role of ion channels in light dependent stomatal opening, Journal of Experimental Botany, Volume 52, Issue 363, Pages 1959–1967, https:// doi.org/10.1093/jexbot/52.363.1959

Sreeman SM, Vijayaraghavareddy P, Sreevathsa R, Rajendrareddy S, Arakesh S, Bharti P, Dharmappa P, Soolanayakanahally R. 2018. Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants. Front. Chem. 6, 92.

Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, (2016). Drought Stress in Plants: Causes, Consequences, and Tolerance. Drought Stress Tolerance in Plants, Vol 1 pp 1-16 Pandey R. 2015. Mineral Nutrition of Plants. 10.1007/978-81-322-2286-6_20.

Barker AV and DJ Pilbeam. 2015. Handbook of Plant Nutrition, Second Edition. Books in Soils, Plants, and the Environment Series, the 2nd Edition, CRC Press.

Vatansever R, Ozyigit II and Filiz E. 2017. Essential and beneficial trace elements in plants, and their transport in roots: a review. Applied biochemistry and biotechnology 181(1), 464- 482.

Tahat MM and Sijam K. 2012. Arbuscularmycorrhizal fungi and plant root exudates biocommunications in the rhizosphere. African Journal of Microbiology Research, 6(46), 7295-7301.

Rajasekar MD, Nandhini DU and Suganthi S. 2017. Supplementation of Mineral Nutrients through Foliar Spray – A Review. Int.J.Curr.Microbiol.App.Sci. 6(3): 2504-2513.https:// doi.org/10.20546/ijcmas.2017.603.283

Tarek A and Hassan ER. 2017. Foliar application: from plant nutrition to biofortification. Environment, Biodiversity and Soil Security. 10.21608/jenvbs.2017.1089.1006.

Course Code: PGPP 0505 Credit Hours: 2+1

Course Title: Hormonal Regulation of Plant Growth and Development

Objectives:

1. To provide knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signalling.
2. To impart knowledge on role in regulating basic physiological processes.
3. To develop understanding on the role of classical hormones on developmental processes.

At the end of the course the students will be able to achieve the following outcomes:

Course Outcome:

CO 1:Understand the role of plant hormones, its discovery and metabolism

CO 2:Enable to understand about various endogenous growth substances other than hormones

CO 3:Gain knowledge on hormone signalling, key genes regulating hormone levels and functions

CO 4:Summarize the Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

CO 5:Acquire knowledge on the Practical Utility of Growth Regulators in Agriculture and Horticulture

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔	✔	
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔		✔

Theory

A. Plant Growth and Development:

1. Introduction to Plant Hormones Hormonal Regulation
2. Plant Hormones - Discovery and Metabolism

3. Physiological Role of Hormones in Plant Growth and DevelopmentEndogenous Growth Substances other than Hormones
4. Hormone Signaling
5. Key Genes Regulating Hormone Levels and Functions
6. Crosstalk of Hormones in Regulation of Plant Growth and Development Processes
7. Practical Utility of Growth Regulators in Agriculture and Horticulture

Block 1: Plant Growth and Development: Hormonal Regulation UNIT I

Introduction to Plant Hormones Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

UNIT II

Plant Hormones – Discovery and Metabolism Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

UNIT III

Physiological Role of Hormones in Plant Growth and Development Physiological functions of

Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroidsand Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

UNIT IV

Endogenous Growth Substances other than Hormones Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

UNIT V

Hormone Signaling Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

UNIT VI

Key Genes Regulating Hormone Levels and Functions Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

UNIT VII

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

UNIT VIII

Practical Utility of Growth Regulators in Agriculture and Horticulture Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

Practical

- Extraction of Auxins from plant tissue
- Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
- Bioassay of auxin- effect on rooting of cuttings
- Extraction of abscisic acid (ABA) from plant tissue
- Separation and detection of ABA by HPLC/Immunological technique
- ABA bioassays- effect on stomatal movement
- Preparation of samples for ethylene estimation in plant tissue
- Estimation of ethylene in plant tissues using gas chromatography
- Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
- Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
- Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
- GA bioassays- effect on germination of dormant seeds
- Cytokinin- extraction from plant tissue
- Separation and detection of cytokinin by GC / GC-MS / HPLC
- Cytokinin bioassays- effect on apical dominance and senescence / stay green

Suggested Reading

Davies P.J. 2004, Plant Hormones: Biosynthesis, Signal Transduction and Action, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Hedden, P. and Thomas, S.J. 2006. Plant Hormone Signalling, Blackwell Publishing Ltd., Oxford, UK.

Osborne, D.J. and McManus, M.T. 2005. Hormones, Signals and Target Cells in Plant

Development. Cambridge University Press, New York, USA.30

Tucker, G.A. and Roberts, J.A. 2000. Plant Hormone Protocols. Humana Press-Springer Science, New York, USA.

Buchanan B B, Gruissem W and Jones R L. Biochemistry and Molecular biology of Plants, 2nd

Edition

Lincoln Taiz and Eduardo Zeiger. Plant Physiology and Development, 6th Edition. Teaching Tools in Plant Biology, The American Society of Plant Biologists The Arabidopsis Book (http://www.arabidopsisbook.org/).

Course Code: PGPP 0507 Credit Hours: 2+1 Course Title: Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling

Objectives:

1. To gain expertise on various aspects of photosynthesis including biophysical, biochemical, and molecular regulations.
2. To impart knowledge on canopy photosynthesis drives, crop growth rates, factors associated with sink activity.
3. To understand the growth and yield prediction models and their relevance

At the end of the course the students will beable to achieve the following outcomes:

Course Outcome:

CO 1: Understand canopy architecture and energy utilization

CO 2: Gain knowledge on photochemical processes and biochemical processes of the plants

CO 3: Realize the concept of product synthesis and translocation

CO 4: Able to understand growth and yield-forming mechanisms **CO 5**: Appreciate yield improvement and modelling

	PSO1	PSO2	PSO3
CO1	✔	✔	
CO2	✔		✔
CO3	✔	✔	

CO4	✔	✔	✔
CO5	✔		✔

Theory Block 1: Photosynthetic Processes UNIT I

Canopy Architecture and Energy Utilization

Parameters associated with canopy architecture that determine radiation interception and absorption, Energy absorption by primary and accessory pigments and energy utilization efficiency, Light distribution inside the canopy and concepts of light eXtinction coefficient.

UNIT I

Photochemical Processes

Ultrastructure of chloroplast: structure and composition of lamellar system, Components of electron transport, Water oxidation system and energy conservation processes, Pigment systems and the generation of a powerful oxidant and a powerful reductant, Chlorophyll fluorescence and fluorescence quenching: qn, qp, NPQ.

UNIT III

Biochemical Processes

CO2 diffusion and resistances (gs and gm). Concept of Ci determining CO2 diffusion. RuBis CO activation state, kinetics and catalytic properties, CarboXylation processes in C3, C4 and CAM plants and their relevance, CO2 concentrating mechanisms and their importance in improving carbon assimilation, Ecological significance of C4 and CAM photosynthesis, Photorespiration and Mitochondrial respiration and net carbon gain, Carbon isotope discrimination and its importance as a surrogate of Ci.

UNIT IV

Product Synthesis and Translocation

Triose phosphate utilization and regulation of Calvin cycle mechanisms, Product synthesis and partitioning between starch and sucrose, Concepts of end-product inhibition or Pi- regeneration limitation, Phloem transport and factors that regulate phloem loading and un-loading.

UNIT V

Growth and Yield forming Mechanisms

Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI and LAD in determining total carbon gain and crop growth rates, Source: Sink relationship and its relevance in governing differences in crop growth rates and productivity. Concepts of HI and partitioning coefficient and remobilization of carbon from vegetative organs to reproductive structures, Growth analysis and parameters that eXplain growth rates: NAR, CGR, HI and their inter-dependence.

Block 2: Yield Improvement and Modelling UNIT I

Molecular Options to Improve Photosynthesis, Growth and Productivity Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities. Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR etc), Theoretical concepts of crop improvement through inducing CCM in C3 plants and reducing photorespiration.

UNIT II

Fundamentals of Dynamic Simulation Models Collection of crop specific genetic coefficient, Crop, soil and historic weather data

UNIT III: Description of Well-established Yield Models Application and limitations of modeling, Yield prediction models such as APSYM, Peanut Grow etc, Machine learning approaches and IoT for making informed on- farm decisions.

UNIT IV

Examples of Robust Models Extensively Used Duncan's yield prediction model, Passioura's model for growth maximising.

Practical

- Plant sampling for leaf area and biomass estimation; analysis of growth and yieldparameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
- Measurement of light interception, light eXtinction coefficient, energy utilization efficiency based energy intercepted, and realized.
- Gas exchange: principles and uses to assess variations in CO2 and water vapour transfer, determination of A/gs and intrinsic WUE
- Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN
- Chlorophyll fluorescence and quenching coefficients
- Theoretical aspects of carbon isotope fractional and its use in determining WUE
- Quantification of RUBISCO content by ELISA (if possible)
- Determination of RUBISCO activity and activation state using radioactive CO-2
- CO2 and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
- Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models

Teaching methods/activities: Lecture, Assignment (Reading/Writing), Student presentation, Practical

Suggested Reading

Goyne, P.J., Milroy, S.P., Lilley, J.M., and Hare, J.M. (1993). Radiation interception, radiation use efficiency and growth of barley cultivars. Australian Journal of

Agricultural Research, 44(6), 1351-1366.https://www.sciencedirect.com/topics/chemistry/photosynthetic- pigment.

Frank, H.A., Young, A., Britton, G., and Cogdell, R.J. (Eds.). (2006). The photochemistry of carotenoids (Vol. 8). Springer Science and Business Media.

Ruban, A.V. (2016). Nonphotochemical chlorophyll fluorescence quenching: mechanism and effectiveness in protecting plants from photodamage. Plant Physiology, 170(4), 1903-1916.

MaXwell, K., and Johnson, G.N. (2000). Chlorophyll fluorescence—a practical guide.

Journal of Experimental Botany, 51(345), 659-668. https://www.researchgate.net/publication/38051229,_The_photochemical_reaction_in_ photosynthesis.

Wang, Y., Stessman, D.J., and Spalding, M.H. (2015). The CO2 concentrating mechanism and photosynthetic carbon assimilation in limiting CO2: how Chlamydomonas works against the gradient. The Plant Journal, 82(3), 429-448.

Dietz, K.J., and Pfannschmidt, T. (2011). Novel regulators in photosynthetic redox control of plant metabolism and gene expression. Plant Physiology, 155(4), 1477-1485.

SUPPORTING COURSES

Course Code: STAT 0502
Credit Hours: 3+1
Course Title: Statistical Methods for Applied Sciences

Objectives:

1. To impart concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.
2. To understanding the concepts involved in data presentation, analysis and interpretation.
3. To train students about presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

At the end of the course students will be able to achieve the following outcomes Course Outcome (CO):

CO1: Gain comprehensive knowledge of fundamental statistical concepts, including descriptive statistics, probability theory, and the principles of exploratory data analysis.

CO2: Understanding discrete and continuous probability distributions their applications in real-world problems. CO3: Proficient in conducting statistical inference, interpreting correlation coefficients, and performing regression analysis.

CO4: Developing skills to perform non-parametric tests as valuable alternatives to parametric tests.

CO5: Students equipped with advanced statistical techniques, enabling effective application of statistical methods in real-world research and analysis.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability.Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood ethods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Hotelling's T2 Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D2- statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

	PSO1	PSO2	PSO3
CO1	✔		
CO2		✔	
CO3		✔	
CO4	✔		
CO5	✔		

Practical

- Exploratory data analysis
- Box-Cox plots; Fitting of distributions Binomial, Poisson, Negative Binomial, Normal
- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F
- Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution

- Correlation and regression analysis, fitting of orthogonal polynomial regression
- Applications of dimensionality reduction and discriminant function analysis Nonparametric tests.

Suggested Reading

Anderson TW. 1958. An Introduction to Multivariate Statistical

Analysis. John Wiley.Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.304

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics.Macmillan.

Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N &

Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley. Learning

Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic

Statistics Text Book:http://www.statsoft.com/textbook/stathome.html.

Course Code: STAT 0511 Credit Hours: 2+1 Course Title: Experimental Designs

Objectives:

1. To understand the concepts involved in planning, designing their experiments and analysis of experimental data
2. To explore the basic principles of experimental design, including the concept of uniformity trials, the size and shape of plots and blocks.
3. To train about fundamental experimental designs (CRD, RBD and LSD) including split plot and strip plot design.

At the end of the course students will be able to achieve the following outcomes:

Course Outcomes:

CO1: Understanding the basic principles of experimental design.

CO2: Enable learners to plan and implement experiments using basic designs (CRD, RBD and LSD)

.

CO3: Familiarized in conducting both symmetrical and asymmetrical factorial experiments

CO4: Execute split plot and strip plot experiments enhancing their agricultural research capabilities.

CO5: Able to use bioassays (direct and indirect) based on quantal dose response.

	PSO1	PSO2	PSO3
CO1	✔	✔	
CO2	✔	✔	
CO3		✔	

CO4		✔	
CO5	✔		

Theory UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation

.**Practical**

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law
- Analysis of data obtained from CRD, RBD, LSD
- Analysis of factorial experiments without and with confounding
- Analysis with missing data
- Split plot and strip plot designs
- Transformation of data
- Analysis of resolvable designs 🎬 Fitting of response surfaces

Suggested Reading

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.

Federer WT. 1985. Experimental Designs. MacMillan.

Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.

Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design

Course Code: STAT 0512 Credit Hours: 2+1 Course Title: Basic Sampling Techniques

Objectives:

1. To expose students to various elementary sampling techniques
2. To understand the concepts involved in planning and designing their surveys
3. To present of result of sample survey data

At the end of the course students will be able to achieve the following outcomes:

Course Outcomes

CO1: Enlighten on different basic terms on sampling techniques

CO2: Students gain exposure about fundamental sampling techniques

CO3: Learning sampling methods (e.g., cluster, systematic, PPS) for effective data collection in research and surveys

CO4: Equip proficiency in using auxiliary information for estimation, employing ratio product and regression estimators to enhance accuracy

CO5: Developing skills in double sampling and the identification and rectification of sampling and non-sampling errors to improve research and survey results

	PSO1	PSO2	PSO3
CO1	✔		
CO2	✔		
CO3	✔		
CO4		✔	
CO5		✔	

Theory UNIT I

Concept of sampling, sample survey *vs* complete enumeration, planning of samplesurvey, sampling from a finite population.

UNIT II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

UNIT III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPSsampling,

UNIT IV

Use of auxiliary information at estimation, Ratio product and regressionestimators.

Double Sampling, sampling and non-sampling errors**.**

Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling
- Estimation using ratio and regression estimators
- Estimation using multistage design, double sampling **Suggested Reading**

Cochran WG. 1977. Sampling Techniques. John Wiley.

Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.

Singh D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.

Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.Cochran WG. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication

Course Code: STAT 0522 Credit Hour: 2+1 Course Title: Data Analysis using Statistical Packages

Objectives:

1. To expose the students in the usage of various statistical packages for analysis of data.
2. To provide the students and hands on experience in the analysis of their research data.
3. To impart the skills to students in carrying out data interpretation and result explanations.

At the end of the course students will be able to achieve the following outcomes:

Course Outcome

CO1: Summarizing and tabulating data, performing descriptive statistics, and creating graphical representations for effective data exploration.

CO2: Fitting and assessing the goodness of fit of probability distributions, as well as conduct hypothesis testing using various statistical tests.

CO3: Performing advanced analyses, including analysis of variance and covariance for different experimental designs.

CO4: Analysing mixed models, estimating variance components, testing contrasts' significance, and conducting correlation and regression analyses.

CO5: Competence in advanced data analysis techniques.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi- square, *t* and *F* statistics.

UNIT III

Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV

Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

- Use of software packages for summarization and tabulation of data
- obtaining descriptive statistics, graphical representation of data
- Robust Estimation, Testing linearity and normality assumption Estimation of trimmed means etc.
- Cross tabulation of data including its statistics cell is play and table format and means for different sub-classifications
- Fitting and testing the goodness of fit of probability distributionsTesting the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*test,st for large samples - Chi-squares test, F test, One way analysis ofvariance , contrast and its testing, pairwise comparisons; Multiway classified analysis ofvariance - cross-classification, nested classification, factorial set up, fixed effect models,random effect models, mixed effect models, estimation of variance components
- Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets – maximum likelihood, ANOVA, REML, MINQUE
- Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis-obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Reading

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.
Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.
Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.
Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis*. Chapman & Hall.
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Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.
Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
Cleveland WS. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
Erickson BH & Nosanchuk TA. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
Snell EJ & Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman & Hall.Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed.
Chapman & Hall.Tufte ER. 1983. *The Visual Display of Quantitative Information*.
Graphics Press, Cheshire, Conn. Velleman PF & Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.
Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.
Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html. Course on
Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.Design
Resources Server: www.iasri.res.in/design. Analysis of Data: Design Resources Server. http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of% 2 Data.html.

COMMON COURSES

The following courses (one credit each) will be offered to all students undergoing Master's degree programme.

Course Code: PGSS 0501 Credit Hours: 0+1 Course Title: Library and Information Services

Objective:

1. To equip the library users with skills to trace information from libraries efficiently.
2. To apprise students abou information and knowledge resources, to carry out literature survey.
3. To formulate information search strategies, with the application of modern tools.

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Acquaint with basic terms of library services

CO2: Understand the methods of tracing information from different source.

CO3: Enable ability to relate one information with another information of interest.

CO4: Gain knowledge on abstracts, review collection, citation, bibliography and tracking information. **CO 5**: Develop ability to compose of review of literatures and scientific reports.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical

- Introduction to library and its services
- Role of libraries in education, research and technology transfer
- Classification systems and organization of library
- Sources of information- Primary Sources, Secondary Sources and Tertiary Sources
- Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.)
- Tracing information from reference sources; Literature survey
- Citation techniques/Preparation of bibliography
- Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services
- Use of Internet including search engines and its resources E-resources access methods.

Course Code: PGSS 0502 Credit Hours: 0+1 Course Title: Technical Writing and Communications Skills

Objective:

1. To equip the students/scholars with skills to write dissertations, research papers, etc.
2. To impart the students/scholars with skills to communicate and articulate in English (verbal as well as writing).
3. To familiarize the students on composing abstracts, review articles, research paper writing etc.

Upon completion of the course the students will be able to achieve the following outcomes:

CO1 Educate about the various forms of writings frequently required in a preparation of documents, reports, manuscripts, manual, etc.

CO2 Develop the understanding of principles and method of effective and professional communication and speech.

CO3 Students able to differentiate among and to use facts, inferences and judgments and editing and proof-reading.

CO4 Enable students to organizing information for research communication, report, thesis and other publication .

CO5 Equip the skills in composing the abstracts, content, notation, citation, captions, pagination, bibliography, review of literature, scientific manuscript, research article, review article, etc.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical Technical Writing

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)
- Writing of abstracts, summaries, précis, citations etc.
- Commonly used abbreviations in the theses and research communications
- Iillustrations, photographs and drawings with suitable captions
- Pagination, numbering of tables and illustrations
- Writing of numbers and dates in scientific write-ups
- Editing and proof-reading; Writing of a review article
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors)
- Concord
- Collocation
- Phonetic symbols and transcription
- Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview 🎬 Presentation of scientific papers.

Suggested Reading

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East- West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.

8. Richard WS. 1969. Technical Writing.
9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
10. Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Code: PGSS 0503 Credit Hours: 1+0 Course Title: Intellectual Property and its Management in Agriculture

Objective:

1. To equip students and stakeholders with knowledge of intellectual property (IPR)
2. To give the significance of fundamentals of patient and copyright policy
3. To impart knowledge and biodiversity protection and initiatives

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Acquaint the meaning of intellectual property and differentiate it from tangible property.

CO2: Understand the process of IPR, their eligibility and various treaties and conventions.

CO3: Develop the ability to analyze TRIPs and various provisions in TRIPS Agreement, GI, ITK.

CO4: To understand protection of plant varieties, researcher's right and farmers' right.

CO5: Enable to evaluate ethical and professional issues that arise in the intellectual property law.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime;

TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection;

Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Reading

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act,

1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

Course Code: PGSS 0504 Credit Hours: 0+1

Course Title: Basic Concepts in Laboratory Techniques

Objective:

1. To acquaint the students about the basics of commonly used techniques in laboratory.
2. To impart various handling techniques and preparation of acid and bases.
3. To learn seed viability testing tissue culture of plants and description of flowering plants Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Educate about basic rules and regulations of laboratory use

CO2: Acquaint with the principles and protocols of commonly used instruments in soil sciences.

CO3: Ability to understand principles and methods of handling chemicals and equipment, preparation of solution, testing samples, etc. in the laboratory.

CO4: Enhance the skills to operate laboratory equipment efficiently and safely

CO5: Students will be able to design appropriate procedure of scientific works in the laboratory in such a way that accuracy of results remains higher.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔

CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Practical

- Safety measures while in Lab
- Handling of chemical substances
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware
- Drying of solvents/chemicals
- Weighing and preparation of solutions of different strengths and their dilution
- Handling techniques ofsolutions; Preparation of different agro-chemical doses in field and pot applications
- Preparation of solutions of acids
- Neutralisation of acid and bases
- Preparation of buffers of different strengths and pH values
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath,waterbath, oilbath
- Electric wiring and earthing. Preparation of media and methods of sterilization
- Seed viability testing, testing of pollen viability
- Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Reading

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press. Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Course Code: PGSS 0505 Credit Hours: 1+0 Course Title: Agricultural Research, Research Ethics and Rural Development Programs

Objective:

1. To enlighten the students about the organization and functioning of agricultural research systems at national and international levels.
2. To impart knowledge in programs and policies of Government.
3. To provide information and evaluation of rural development policies and programs.

Upon completion of the course the students will be able to achieve the following outcomes:

CO1: Impart the knowledge about basics of Agricultural Research, Research Ethics and Rural Development Programs in India

CO2: Develop the understanding of research ethics

CO3: Ability to develop and understanding of rural developmental programs, policies, strategies and their evaluation system.

CO4 ::Get insights into intensive agriculture development programs.

CO5 : Able to analyze the constraints in implementation of rural policies and programs.

	PSO1	PSO2	PSO3
CO1	✔	✔	✔
CO2	✔	✔	✔
CO3	✔	✔	✔
CO4	✔	✔	✔
CO5	✔	✔	✔

Theory UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities;

Role in promoting food security, reducing poverty and protecting the environment; National

Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions;

Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive

Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural

Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Reading

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.