

Credit Distribution of M.Sc. (Ag.) Agronomy

Semester wise course breakup

S.N.	Code	Name of the course	Credits
1	AGRON 503	Principles and Practices of Weed Management	3(2+1)
2	AGRON 512	Dry Land Farming and Watershed Management	3(2+1)
3	AGRON 550	Seminar	1(1+0)
4	SOIL -503	Soil Chemistry (MINOR)	3(2+1)
5	PGS- 505	Agricultural Research, Research Ethics and Rural Development programme	1(1+0)
6	AGRON -560	Thesis research	10(0+10)
		Total	21(8+13)

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Semester IV

S.N.	Code	Name of the course	Credits
1	SOIL - 510	Analytical Techniques and Instrument Methods in soil & plant Analysis (MINOR)	2(0+2)
2	AGRON - 560	Thesis research	20(0+20)
		Total	22(0+22)
		Grand Total	71 (27+44)

Note :

Thesis topic may be allotted from second semester.

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Department of Natural Resource Management
Faculty of Agriculture
Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, M.P.

M.Sc. Ag. (Agronomy)

SN	Code		
A.1		Major Course	21 Credit (L+P)
1.	AGRON -501	Modern Concept in Crop Production	3(3+0)
2.	AGRON -502	Principles & Practices of Soil Fertility and Nutrient Management	3(2+1)
3.	AGRON -503	Principles and Practices of Weed Management	3(2+1)
4.	AGRON -504	Principles and Practices of Water Management	3(2+1)
5.	AGRON -506	Agronomy of Major Cereals and Pulses	2(2+0)
6.	AGRON -507	Agronomy of Oilseed, Fibre and Sugar Crops	3(2+1)
7.	AGRON -512	Dry Land Farming and Watershed Management	3(2+1)
8.	AGRON -550	Seminar	1(1+0)
A.2		Minor Course	08 Credits (L+P)
1.	SOIL -501	Soil Physics	3(2+1)
2.	SOIL -503	Soil Chemistry	3(2+1)
3.	SOIL - 510	Analytical Techniques and Instrument Methods in soil & plant Analysis	2(0+2)
B.		Supporting Course	07 Credits (L+P)
1.	STAT 502	Statistical Methods for Applied Sciences	4(3+1)
2.	STAT-511	Experimental Designs	3(2+1)
C.		Common Course	05 Credits (L+P)
1.	PGS- 501	Library & Information Services	1(0+1)
2.	PGS- 502	Technical Writing and Communication Skills	1(0+1)
3.	PGS- 503	Intellectual property write and its management in Agricultural	1(0+1)
4.	PGS- 504	Basic Concept in Laboratory Techniques	1(0+1)
5.	PGS- 505	Agricultural Research, Research Ethics and Rural Development programme	1(1+0)
D.	AGRON -560	Thesis research (Master's research)	30 credits
		Grand Total	71 Credits



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Course Contents

M.Sc. in Agronomy

- I. Course Title : Modern Concepts in Crop Production
II. Course Code : Agron 501
III. Credit Hours : 3+0

IV. Aim of the course

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

V. 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 technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

VI. Teaching methods/activities

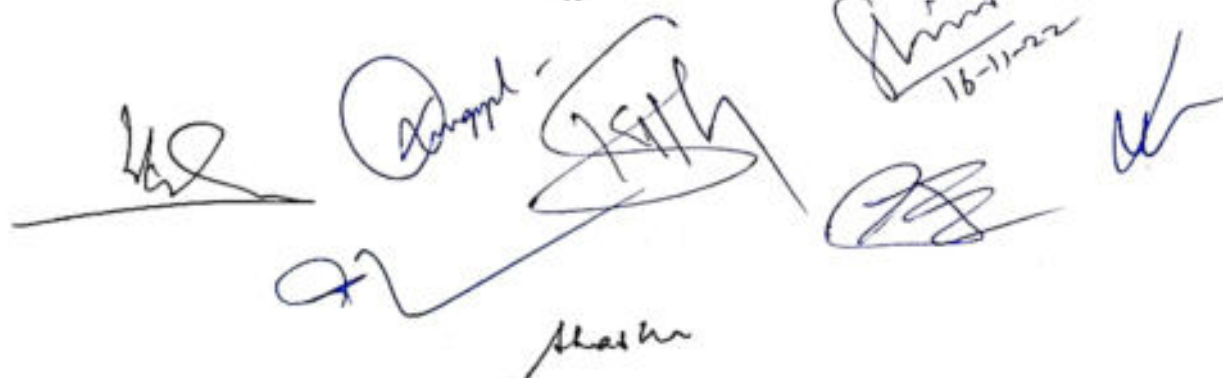
Classroom teaching with AV aids, group discussion, assignment and class discussion

VII. Learning outcome

Basic knowledge on soil management and crop production

VIII. Suggested Reading

- Balasubramanian P and Palaniappan SP. 2001. *Principles and Practices of Agronomy*. Agrobios.
- Fageria NK. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and 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 and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Alvin PT and Kozlowski TT (ed.). 1976. *Ecophysiology of Tropical Crops*. Academia Pul., New York.
- Gardner PP, Pearce GR and Mitchell RL. 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 CP. 1961. *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

I. Course Title : **Principal and Practices of Soil Fertility and Nutrient Management**

II. Course Code : **Agron 502**

III. Credit Hours : **2+1**

IV. Aim of the course

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

V. 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 fertilizer use efficiency; nutrient interactions.

Unit V

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

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**VI. Practical**

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

VIII. Learning outcome

Basic knowledge on soil fertility and management

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. *Growth and Mineral Nutrition of Field Crops*. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. *Soil Fertility and Fertilizers*. 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. *Manures and Fertilizers*. Agri-Horti Publ.

I. Course Title : Principles and Practices of Weed Management

II. Course Code : Agron 503

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory

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

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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.

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

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit to identify weeds.

VIII. Learning outcome

Basic knowledge on weed identification and control for crop production

IX. Suggested Reading

- Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.
- Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.
- Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).
- Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.
- Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.
- Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press
- Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley
- Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.
- Walia US. 2006. *Weed Management*, Kalyani.
- Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture*, B. D. Sci. Pub.

I. Course Title : Principles and Practices of Water Management

II. Course Code : Agron 504

III. Credit Hours : 2+1

IV. Aim of the course

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

V. 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, extent of area and crops irrigated in India and in different states.

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**Unit II**

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

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.

VI. 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

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- 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

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

VIII. Learning outcome

Basic knowledge on water management for optimization of crop yield

IX. Suggested Reading

- Majumdar DK. 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 and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.
- Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
- Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

I. Course Title : Conservation Agriculture

II. Course Code : Agron 505

III. Credit Hours : 1+1

IV. Aim of the course

To impart knowledge of conservation of agriculture for economic development.

V. 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

VI. Practicals

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Estimation of C-sequestration,
- Machinery calibration for sowing different crops, weed seedbank estimation under CA, energy requirements, economic analysis of CA.

VII. Teaching methods/activities

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

VIII. Learning outcome

Experience on the knowledge of various types of conservation of agriculture.

IX. Suggested Reading

- Arakeri HR and Roy D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & IBH.
- Bisht JK, Meena VS, Mishra PK 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.
- 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.
- Gracia-Torres L, Benites J, Martinez-Vilela A and Holgado-Cabera A. 2003. Conservation Agriculture- Environment Farmers experiences, innovations Socio-economic policy.
- Muhammad F and Kamdambot HMS. 2014. Conservation Agriculture. Publisher: Springer Cham Heidelberg, New York Dordrecht London. Doi: 10.1007/978-3-319-11620-4.
- Yellamanda Reddy T and Sankara Reddy GH. 1992. *Principles of Agronomy*. Kalyani.

I. Course Title : Agronomy of Major Cereals and Pulses

II. Course Code : Agron 506

III. Credit Hours : 2+0

IV. Aim of the course

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

V. 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.

VI. Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Working out growth indices (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 ratio, 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

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

VIII. Learning outcome

Basic knowledge on cereals and pulse growing in the country .

IX. Resources

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Hunsigi G and Krishna KR. 1998. *Science of Field Crop Production*. Oxford & IBH.
- Jeswani LM and Baldev B. 1997. *Advances in Pulse Production Technology*. ICAR.
- Khare D and Bhale MS. 2000. *Seed Technology*. Scientific Publ.
- Kumar Ranjeet and Singh NP. 2003. *Maize Production in India: Golden Grain in Transition*. IARI, New Delhi.
- Pal M, Deka J and 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 and Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.
- Yadav DS. 1992. *Pulse Crops*. Kalyani.

I. Course Title : Agronomy of Oilseed, Fibre and Sugar Crops

II. Course Code : Agron 507

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory

Origin and history, area and production, classification, improved varieties,

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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.

VI. Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (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 ratio, 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

VIII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

IX. Learning outcome

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

X. Suggested Reading

- Das NR. 2007. *Introduction to Crops of India*. Scientific Publ.
- Das PC. 1997. *Oilseed Crops of India*. Kalyani.
- Lakshmikantham N. 1983. *Technology in Sugarcane Growing*. 2nd Ed. Oxford & IBH.
- Prasad Rajendra. 2002. *Text Book of Field Crop Production*. ICAR.



- Singh C, Singh P & Singh R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Singh SS. 1998. *Crop Management*. Kalyani.

I. Course Title : Agronomy of Medicinal, Aromatic and Under Utilized Crops

II. Course Code : Agron 508/PSMA 503

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory

Unit I

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

Unit II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, 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.

VI. Practical

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

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

VIII. Learning outcome

Acquainted with various MAP and their commercial base for developing entrepreneurship.

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inputs and low cost technologies; research need on sustainable agriculture.

Unit IV

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

VII. Teaching methods/ activities

Classroom teaching with AV aids, group discussion, assignment.

VIII. Learning outcome

Basic knowledge on cropping system for sustainable agriculture.

IX. Suggested Reading

- Panda SC. 2017. *Cropping Systems and Sustainable Agriculture*. Agrobios (India)
- Panda SC. 2018. *Cropping and Farming Systems*. Agrobios.
- Palaniappan SP and 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 and Mudaliar TVS. 1997. *Principles of Agronomy*. The Bangalore Printing & Publ. Co.
- Singh SS. 2006. *Principles and Practices of Agronomy*. Kalyani.
- Tisdale SL, Nelson WL, Beaton JD and Havlin JL. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

I. Course Title : Dryland Farming and Watershed Management

II. Course Code. : Agron 512

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory

Unit I

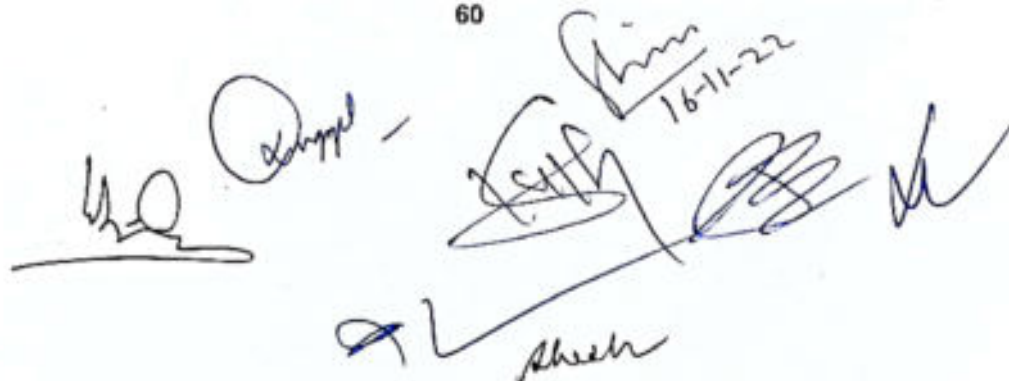
Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

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,


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drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Unit IV

Tillage, tillth, 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.

VI. 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 by 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

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment.

VIII. Learning outcome

Basic knowledge on dry land farming and soil moisture conservation.

IX. Suggested Reading

- Reddy TY. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers
- Das NR. 2007. *Tillage and Crop Production*. Scientific Publ.
- Dhopte AM. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.
- Dhruv Narayan VV. 2002. *Soil and Water Conservation Research in India*. ICAR.
- Gupta US. (Ed.). 1995. *Production and Improvements of Crops for Drylands*. Oxford & IBH.
- Katyal JC and Farrington J. 1995. *Research for Rainfed Farming*. CRIDA.
- Rao SC and Ryan J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publ.
- Singh P and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ. Company.
- Singh RP. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.
- Singh RP. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.
- Singh SD. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publ.
- Venkateshwarlu J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

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Course Title with Credit Load M.Sc. in Soil Science

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

*Indicates Core Courses which are Compulsory for Master Programme













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Course contents

M.Sc. in Soil Science

- I. Course Title : Soil Physics
II. Course Code : Soil 501
III. Credit Hours : 2+1

IV. Aim of the course

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

V. Theory

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

Soil texture, textural classes, mechanical analysis, specific surface.

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

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Unit IX

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

VI. Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

VII. Teaching methods/activities

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

VIII. Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

IX. Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP and Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR and Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
- Hillel D. 1998. *Environmental Soil Physics*. Academic Press. *
- Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

I. Course Title : Soil Fertility and Fertilizer Use

II. Course Code : Soil 502

III. Credit Hours : 3+1

IV. Aim of the course

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

V. Theory

Unit I

Soil fertility and soil productivity; fertility status of major soils group of India;

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VIII. Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.
- Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.
- Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.
- Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.
- Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.
- Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

I. Course Title : Soil Chemistry

II. Course Code : Soil 503

III. Credit Hours : 2+1

IV. Suggested Reading

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

V. Theory

Unit I

Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

Unit III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange-

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innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

Unit V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/I) relationship; step and constant-rate K; management aspects.

Unit VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit VII

Chemistry of salt-affected soils and amendments; soil pH, E_{ce}, ESP, SAR and important relations; soil management and amendments.

Unit VIII

Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

VI. Practical

Preparation of saturation extract, measurement of pH, EC, CO₃, HCO₃, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E₄/E₆) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E₄/E₆) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl₂-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

VII. Teaching methods/activities

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

VIII. Learning outcome

Experience on the knowledge of chemical behaviour of soil and their utility in research for solving field problem.

IX. Suggested Reading

- Bear RE. 1964. *Chemistry of the Soil*. Oxford and IBH.
- Bolt GH and Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.
- Greenland DJ and Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.
- Greenland DJ and Hayes MHB. *Chemistry of Soil Constituents*. John Wiley & Sons.
- McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.
- Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford University Press.
- Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford University Press.

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**VII. Learning outcome**

Development of confidence for setting soil testing laboratory.

VIII. Suggested Reading

- Hesse P. 1971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
- Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
- Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
- Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.
- Page AL, Miller RH and Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
- Piper CE. *Soil and Plant Analysis*. Hans Publ.
- Singh D, Chhonkar PK and Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.
- Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Waters*. FDCO, New Delhi.
- Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

I. Course Title : Management of Problem Soils and Water

II. Course Code : Soil 511

III. Credit Hours : 2+1

IV. Aim of the course

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

V. Theory**Unit I**

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

Unit II

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

Unit III

Management of salt-affected soils; salt tolerance of crops- mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soils alinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

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

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

IX. Suggested Reading

- Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
- Lillesand TM and Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
- Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statistics*. Catena Verlag GmbH.
- Star J and Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

I. Course Title : Analytical Technique and Instrumental Methods in Soil and Plant Analysis

II. Course Code : Soil 510

III. Credit Hours : 0+2

IV. Aim of the course

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

V. Practical**Unit I**

Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

VI. Teaching methods/activities

Classroom teaching and laboratory practicals

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- Sposito G. 1989. *The Chemistry of Soils*. Oxford University Press.
- Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley & Sons.
- Van Olphen H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

- I. Course Title : Soil Mineralogy, Genesis and Classification
 II. Course Code : Soil 504
 III. Credit Hours : 2+1
 IV. Aim of the course

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

V. Theory

Unit I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystal line and non-crystal line clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Unit III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit IV

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

VI. Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions
- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soil using available database in terms of soil quality

VII. Teaching methods/activities

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

VIII. Learning outcome

Experience on the knowledge of soil taxonomy and genesis and their utility in research for solving field problem.

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Course Title with Credit Load M.Sc. in Agricultural Statistics

Course Code	Course Title	Credit Hours	Semester
*STAT 552	Probability Theory	2+0	I
*STAT 553	Statistical Methods	2+1	I
*STAT 562	Statistical Inference	2+1	II
*STAT 563	Design of Experiments	2+1	II
*STAT 564	Sampling Techniques	2+1	II
*STAT 565	Statistical Genetics	2+1	II
*STAT 571	Multivariate Analysis	2+1	III
*STAT 572	Regression Analysis	1+1	III
*STAT 573	Statistical Computing	1+1	III
STAT 591	Seminar	0+1	III
STAT 599	Research	0+30	II-IV
STAT 551	Mathematics-I	3+0	I
STAT 554	Actuarial Statistics	2+0	I
STAT 555	Bioinformatics	2+0	I
STAT 556	Econometrics	2+0	I
STAT 561	Mathematics-II	2+0	II
STAT 566	Statistical Quality Control	2+0	II
STAT 567	Optimization Techniques	1+1	II
STAT 574	Time Series Analysis	1+1	III
STAT 575	Demography	2+0	III
STAT 576	Statistical Methods for Life Sciences	2+0	III
STAT 577	Statistical Ecology	2+0	III
Supporting Courses			
STAT 501	Mathematics for Applied Sciences	2+0	I
STAT 502	Statistical Methods for Applied Sciences	3+1	I
STAT 511	Experimental Designs	2+1	II
STAT 512	Basic Sampling Techniques	2+1	II
STAT 521	Applied Regression Analysis	2+1	III
STAT 522	Data Analysis Using Statistical Packages	2+1	III

*Core Courses

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Course Contents

M.Sc. in Agricultural Statistics

- I. Course Title : Mathematics for Applied Sciences
II. Course Code : STAT 501
III. Credit Hours : 2+0
IV. Aim of the course

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equations etc.

V. Theory

Unit I

Set theory-set operations, finite and infinite sets, operations of set, function.

Unit II

Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solutions of Linear Equations.

Unit III

Variables and functions, limits and continuity of specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

Unit IV

Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in Agriculture, Differential Equations.

VI. Suggested Reading

- Hohn F.E. 2013. *Elementary Matrix Algebra*, 3rd Ed., Kindle Edition
- Harville D.A. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
- Hohn F.E. 1973. *Elementary Matrix Algebra*. Macmillan.
- Searle S.R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.
- Stewart J. 2007. *Calculus*. Thompson.
- Thomas G.B. Jr. and Finney R.L. 1996. *Calculus*. 9th Ed. Pearson Edu.

- I. Course Title : Statistical Methods for Applied Sciences
II. Course Code : STAT 502
III. Credit Hours : 3+1
IV. Aim of the course

This course is meant for students who do not have sufficient background of Statistical



Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

V. Theory

Unit I

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.

Unit III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

Unit IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

Unit V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

VI. Practical

- Exploratory data analysis, 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 Correlation and regression analysis, fitting of Linear and Quadratic Model.
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

VII. Suggested Reading

- Goon A.M, Gupta M.K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- Hoel P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
- Hogg R.V and Craig T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
- Morrison D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
- Hogg RV, McKean JW, Craig AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.
- Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
- Anderson TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed . John Wiley

- <http://freestatistics.altervista.org/en/learning.php>.
- <http://www.statsoft.com/textbook/stathome.html>.

- I. Course Title : Experimental Designs
 II. Course Code : STAT 511
 III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

V. 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. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

VI. 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,
- Analysis with missing data,
- Split plot and strip plot designs.

VII. Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.
- Federer WT. 1985. *Experimental Designs*. MacMillan.
- Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
- Nigam AK and 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.
- www.dra.icar.gov.in.

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Course Code	Course Title	Credit Hours
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

2.3 Syllabus of Common Courses for PG programmes

PGS 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

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

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;

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- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*.
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.
9. Richard WS. 1969. *Technical Writing*.
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

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

1. Erbis FH and 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 and 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 and 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; The Biological Diversity Act, 2002.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

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

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

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2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

pg 555 **AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)**

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR); International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

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

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and 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.

2.4 Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latest developments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters'

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