DEPARTMENT OF AGRONOMY
PROGRAMMES: M.Sc. (Ag.)-Agronomy

COURSE REQUIREMENTS

Field of specialization	Crop production, Nutrient management, Weed management, Water management, Crop physiology, Organic farming
Core courses	AGRON 511, AGRON 512, AGRON 513, AGRON 531
Optional courses	AGRON 521, AGRON 522, AGRON 523, AGRON 524, AGRON 525, AGRON 526, AGRON 532, AGRON 533, AGRON 534, AGRON 535, AGRON 536
Minor & supporting courses	STAT 511, STAT 521, PPHYS 521, PPHYS 522, SCHEM-521, SCHEM-523 or as per decision of advisory committee in view of research problem
Non credit compulsory courses	PGS 501, PGS 502, PGS 503, PGS 504 PGS 505 PGS 506 AGRON-542 (Comprehensive), AGRON-543 (Master research)
Deficiency courses	Nil or as deemed suitable by advisory committee

Semester wise total major courses offered by Department of Agronomy for M.Sc. (Ag.)

Course No.	Title	Credit Points
	Semester - I	
AGRON-511*	Principles and practices of water management	3 (2+1)
AGRON-512*	Principles and practices of weed management	3 (2+1)
AGRON-513*	Principles and practices of soil fertility and nutrient Management	3 (2+1)
	Semester - II	
AGRON-521	Agro meteorology and Crop weather forecasting	3 (2+1)
AGRON-522	Principles of soil management and crop production	3(3+0)
AGRON-523	Soil conservation and watershed management	3(2+1)
AGRON-524	Dry land farming	3 (2+1)
AGRON-525	Cropping system and sustainable Agriculture	3(3+0)
AGRON-526	Agronomy of major cereals and pulses	3 (2+1)
	Semester - III	
AGRON-531*	Modern Concept in crop production	3(3+0)
AGRON-532	Agronomy of oilseeds and fibre crops	3 (2+1)
AGRON-533	Agronomy of fodder and forage crops	3(2+1)
AGRON-534	Agronomy of medicinal, aromatic and under-utilized crops	3(2+1)
AGRON-535	Agrostology and agro-forestry	3(2+1)
AGRON-536	Principles and practices of organic farming	3(2+1)
AGRON-541	Masters Seminar	1 (0+1)
	Semester – IV	
AGRON-542	Comprehensive	NC
AGRON-543	Masters research	20

*Core Course

Semester wise total minor, supporting and non-credit courses of Department of Agronomy for M.Sc. (Ag.)*

Course No.	Title	Credit Points
Semester - I		
STAT-511	Statistical methods	3 (2+1)
PGS-501**	Library & Information Services	1 (0+1)
PGS-502**	Technical writing and communication skills	1(0+1)
Semester - II		
STAT-521	Design of Experiments-I	3(2+1)
SCHEM-521	Soil biology and biochemistry	3(2+1)
SCHEM-523	Remote sensing and GIS techniques for soil, water and crop studies	3(2+1)
PGS-503**	Intellectual property and Its management in agriculture	1 (1+0)
PGS-504**	Basic concepts in Laboratory techniques	1 (0+1)
Semester - III		
PPHYS-521	Principles of Plant Physiology	3(2+1)
PPHY-522	Physiological & molecular response of plants to abiotic stresses	3(2+1)
PGS-505**	Agricultural research, research Ethics and rural development programme (e-Course)	1 (1+0)
PGS-506**	Disaster Management	1 (1+0)

*Courses will be offered to the students as per the availability of faculty, **Non credits essential course

AGRON-511: PRINCIPLES AND PRACTICES OF WEED MANAGEMENT 3 (2+1)

Theory

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

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

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

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

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

Practical

1. Identification of important weeds of different crops
2. Preparation of a weed herbarium
3. Weed survey in crops and cropping systems
4. Crop-weed competition studies
5. Preparation of spray solutions of herbicides for high and low-volume sprayers
6. Use of various types of spray pumps and nozzles and calculation of swath width
7. Economics of weed control
8. Herbicide resistance analysis in plant and soil • Bioassay of herbicide resistance
9. Calculation of herbicide requirement

AGRON-512: PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 3 (2+1)

Theory

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

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

UNIT III: Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; micro-irrigation system; fertigation; management of water in controlled environments and polyhouses.

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

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

Practical

1. Measurement of soil moisture by using tensiometer, and pressure plate and membrane, apparatus
2. Soil-moisture characteristics curves
3. Water flow measurements using different devices
4. Determination of irrigation requirements

5. Calculation of irrigation efficiency
6. Determination of infiltration rate
7. Determination of saturated/unsaturated hydraulic conductivity

AGRON-513: PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT

3 (2+1)

Theory

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

UNIT II: Criteria of essentiality of nutrients; essential plant nutrients: their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

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

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

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

Practical

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

AGRON-521: AGROMETEOROLOGY AND CROP WEATHER FORECASTING 3(2+1)

Theory

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

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

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

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

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

Practical

1. Visit to agro-meteorological observatory and to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure
2. Measurement of solar radiation outside and within plant canopy
3. Measurement/estimation of evapo-transpiration by various methods
4. Measurement/estimation of soil water balance
5. Rainfall variability analysis
6. Determination of heat-unit requirement for different crops
7. Measurement of crop canopy temperature
8. Measurement of soil temperatures at different depths
9. Remote sensing and familiarization with agro-advisory service bulletins

10. Study of synoptic charts and weather reports, working principle of automatic weather station
11. Visit to solar observatory

AGRON-522: PRINCIPLES OF SOIL MANAGEMENT AND CROP PRODUCTION 3(3+0)

Theory

UNIT I: Tillage: definition, objectives, types and its effect on physical properties on soil; Concept of zero tillage; concept of minimum tillage.

UNIT II: Soil fertility management in crop production: Plant nutrients – criteria of essentiality and forms of uptake, Role and deficiency symptoms of plant nutrients; Concept of balanced fertilization and integrated nutrient management; Nutrient management in cereal/ pulse based cropping systems; Concepts regarding

UNIT III: Precision farming and Site specific nutrient management; Organic matter : Importance, benefits, composition and decomposition; Factors affecting decomposition and detrimental effects; Crop residue management ; Classification and reclamation of saline and sodic soils; Management of saline and sodic soils.

UNIT IV: Constraints/Problems of crop production in different agro-climatic zones of Rajasthan; Seeds and their role in crop production; Concepts of optimum plant population, planting geometry and ideal plant type; Concepts regarding cropping systems-monoculture, crop rotation, multiple , Cropping, relay cropping, mixed cropping and intercropping;

UNIT V: Water stress in relation to crop growth; Soil fertility and moisture interaction; Agronomic manipulation for higher yield in dryland agriculture; Excess soil water and crop growth; Agronomic practices for poorly drained soils; Weed management in crop production

AGRON-523: SOIL CONSERVATION AND WATERSHED MANAGEMENT 3(2+1)

Theory

UNIT I: Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

UNIT II: Soil conservation: definition, methods of soil conservation; agronomic measures: contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures: bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III: Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

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

UNIT V: Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Practical

1. Study of different types of erosion
2. Field studies of different soil conservation measures
3. Run-off and soil loss measurements
4. Laying out run-off plot and deciding treatments
5. Identification of different grasses and trees for soil conservation
6. Visit to a soil conservation research centre, demonstration and training centre

AGRON-524: DRYLAND FARMING 3(2+1)

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

1. Seed treatment, seed germination and crop establishment in relation to soil moisture contents
2. Moisture stress effects and recovery behaviour of important crops
3. Estimation of moisture index and aridity index

4. Spray of anti-transpirants and their effect on crops
5. Collection and interpretation of data for water balance equations
6. Water use efficiency
7. Preparation of crop plans for different drought conditions
8. Study of field experiments relevant to dryland farming
9. Visit to dryland research stations and watershed projects

AGRON-525: CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE 3(3+0)

Theory

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

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

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

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

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

AGRON-526: AGRONOMY OF MAJOR CEREALS AND PULSES 3(2+1)

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: Wheat & barley

UNIT II: *Kharif* cereals: Paddy, maize, sorghum & pearl millet

UNIT III: *Rabi* pulses: Chick pea

UNIT IV: *Kharif* pulses: Pigeon pea

Practical

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

AGRON-531: MODERN CONCEPTS IN CROP PRODUCTION 3(3+0)

Theory

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

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

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

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

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

AGRON-532: AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS 3(2+1)

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 & mustard, linseed.

UNIT II: *Kharif* oilseeds-Groundnut, sesame, soybean etc.

UNIT III: Fiber crops-Cotton, sunhemp.

UNIT IV: Sugar crops-Sugarcane.

Practical

1. Planning and layout of field experiments
2. Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane
3. Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
4. Intercultural operations in different crops
5. Cotton seed treatment
6. Working out growth indices (LER, CGR, RGR, NAR, LAD) aggressivity, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems

7. Judging of physiological maturity in different crops and working out harvest index
8. Working out cost of cultivation of different crops
9. Estimation of crop yield on the basis of yield attributes
10. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
11. Determination of oil content in oilseeds and computation of oil yield
12. Estimation of quality of fibre of different fibre crops
13. Study of seed production techniques in various crops
14. Visit of field experiments on cultural, fertilizer, weed control and water management aspects
15. Visit to nearby villages for identification of constraints in crop production

AGRON-533: AGRONOMY OF FODDER AND FORAGE CROPS 3(2+1)

Theory

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

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

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

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

UNIT V: Economics of forage cultivation uses and seed production techniques.

Practical

1. Practical raining of farm operations in raising fodder crops
2. Canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops
3. Anti-quality components like HCN in sorghum and such factors in other crops

4. Hay and silage making and economics of their preparation

AGRON 534- AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS 3(2+1)

Theory

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

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

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

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

Practical

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

AGRON-535: AGROSTOLOGY AND AGRO-FORESTRY 3(2+1)

Theory

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

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

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

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

Practical

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

AGRON-536: PRINCIPLES AND PRACTICES OF ORGANIC FARMING 3(2+1)

Theory

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

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

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

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

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

Practical

1. Aerobic and anaerobic methods of making compost
2. Making of vermicompost
3. Identification and nursery raising of important agro-forestry tress and tress for shelter belts
4. Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
5. Visit to an organic farm
6. Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

MINOR & SUPPORTING COURSES

STAT- 511: STATISTICAL METHODS 3(2+1)

Theory

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

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, Nonparametric tests.

STAT-521 DESIGN OF EXPERIMENTS-I 3(2+1)

Theory

Basic principles of design of experiments, Uniformity trials and their uses, Fair field Smiths Variance Law and optimum size and shape of plots. Efficiency of basic designs. Factorial experiments: Symmetrical and Asymmetrical factorial experiments, 2^n factorial experiments, Yates method and general method of analysis of A x B and A x B x C factorial experiments. Confounding in case of 2^n factorial experiments, Complete and partial confounding. Layout and analysis of Split and Strip plot design. Missing plot technique in R.B.D. and L.S.D. with one observation missing. Progeny Row trial and compact family block design. Transformations: Square root, Logarithmic and Angular transformation. Analysis of Covariance.

Practicals

Analysis of 2^2 and 2^3 experiments in R.B.D., Analysis of AxB factorial experiments. Analysis of A x B x C factorial experiments, Complete confounding in case of 2^3 experiments, Partial confounding in case of 2^3 experiments, Missing plot analysis in case of R.B.D. with one observation missing, Missing plot analysis in case of L.S.D. with one observation missing. Analysis of Split plot and Strip plot design, Analysis of Covariance in case of R.B.D. Use of transformations

PPHY-521: PRINCIPLES OF PLANT PHYSIOLOGY 3(2+1)

Theory:

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane: structure and functions. Soil and plant water uptake, water and its role in plants, properties and functions of water in the cell water relations, cell water terminology, water potential of plant cells. Mechanism of water uptake by root, transport in root, aquaporins, movements of water in plants, Micorrhizal association on water uptake. Water loss from plants: Evapo-transpiration, Transpiration, driving force for transpiration, plant factors influencing transpiration rate. Stomata: structure and function, mechanism of stomatal movement, antitranspirants. The role of mineral nutrition in plant metabolism: essential elements, classification based on functions of elements in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity, foliar nutrition. Photosynthesis and its importance in bio-productivity. Photochemical process, photochemical reactions, CO2 reduction in calvin cycle, supplementary pathway of CO2 fixation in C4 and CAM plants and its significance. Mitochondrial respiration Growth and differentiation, Hormonal concept of growth and differentiation, plant growth hormones and their physiological role, synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. **Seed Physiology, seed dormancy, viability, method to overcome dormancy and its significance.**

Practical:

1. Measurement of plant water status: RWC, WSD, VPD.
2. Measurement of transpiration rate: Porometry study,
3. Influence of ABA on stomatal closing.
4. Deficiency systems of nutrients.
5. Estimation of chlorophyll and chlorophyll stability index.
6. Oxygen evolution during photosynthesis.

Note: Written in bold showed addition of topic(s) in the course

PPHY-522: PHYSIOLOGICAL & MOLECULAR RESPONSE OF PLANTS TO ABIOTIC STRESSES 3(2+1)

Theory:

Response of plants to abiotic stress: Abiotic stresses affecting plants productivity. Basic principles of crop improvement programme under stress. Interaction between biotic and abiotic stress. Development of water deficits, energy balance concept. Physiological process affected by drought, drought resistance mechanism, Molecular response to water deficit: stress perception. Expression of regulatory and genes and significance of gene products. Stress and hormones: ABA as a signaling molecule, cytokinin as a negative singnal. Oxidative stress: ROS, Role of scavenging system (SOD, Catalase etc.). High temperature stress tolerance mechanism. Chilling stress: Effect on physiological processes. Salinity: Salt tolerance mechanism, **effect of salt stress on plant productivity, SOS pathway.**

Practical:

1. Measurement of drought tolerance on the basis of chlorophyll stability index,
2. Measurement of drought tolerance on the basis of cell membrane stability,
3. Measurement of salt tolerance on the basis of cell membrane stability
4. Effect of drought on transpiration
5. Effect of salinity on transpiration

Note: Written in bold showed addition of topic(s) in the course

SCHEM-521: SOIL BIOLOGY AND BIOCHEMISTRY 3(2+1)

Theory

UNIT I: Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II: Microbiology and biochemistry of root-soil interface; phyllosphere and rhizosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV: Biodegradation of organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V: Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI: Biofertilizers: definition, classification, specifications, method of production and role in crop production. BIS standards for quality control.

Practical

1. Determination of soil microbial population
2. Soil microbial biomass (C, N and P)
3. Fractionation of organic matter and functional groups
4. Soil enzymes
5. Measurement of soil microbial processes such as nitrification, N2 fixation, S oxidation, P solubilization

SCHEM-523: REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES 3(2+1)

Theory

UNIT I: Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.

UNIT II: Sensor systems: camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations.

UNIT III: Application of remote sensing techniques: land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

UNIT IV: Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

UNIT V: Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

1. Familiarization with different remote sensing equipments and data products
2. Interpretation of aerial photographs and satellite data for mapping of land
3. resources
4. Analysis of variability of different soil properties with classical and geostatistical
5. techniques
6. Creation of data files in a database programme
7. Use of GIS for soil spatial simulation and analysis
8. To enable the students to conduct soil survey and interpret soil survey
9. reports in terms of land use planning

DEPARTMENT OF AGRONOMY

PROGRAMMES: Ph.D. (Agronomy)

COURSE REQUIREMENTS

Field of specialization	Crop production, Nutrient management, Weed management, Water management, Crop physiology, organic farming, Cropping systems
Core courses	AGRON 611, AGRON 612
Optional courses	AGRON 613, AGRON 614, AGRON 621, AGRON 622, AGRON 623, AGRON 624
Minor & supporting courses	STAT 521, STAT 531, PPHYS 511, PPHYS 622, SCEHEM 521, SCEHEM 611 or as per decision of advisory committee in view of research problem
Doctoral Seminar	AGRON-691 (Doctoral Seminar-I), AGRON-692 (Doctoral Seminar-II),
Non-credit compulsory courses	PGS 501, PGS 502, PGS 503, PGS 504, PGS 505, PGS 506 (Exempted if done in M.Sc.), AGRON-641 (Comprehensive) AGRON-699 (Doctoral Research)
Deficiency courses	Nil or as deemed suitable by advisory committee

Semester wise total major courses of Department of Agronomy for Ph.D. programme

Subject Code	Subject Title	Credit Hours
Semester-I		
AGRON-611*	Advances in crop growth and productivity	3(2+1)
AGRON-612*	Advances in Weed Management	3(2+1)
AGRON-613	Irrigation management	3(2+1)
AGRON-614	Crop ecology	3(3+0)
AGRON-691	Doctoral Seminar-I	1(0+1)
Semester-II		
AGRON-621	Current Trends in Agronomy	3(3+0)
AGRON-622	Stress Crop Production	3(2+1)
AGRON-623	Integrated Farming Systems for Sustainable Agriculture	3(3+0)
AGRON-624	Crop production and system modeling	3(2+1)
AGRON-692	Doctoral Seminar-II	1(0+1)
Semester-III to VI		
AGRON-641	Comprehensive	NC
AGRON-699	Doctoral Research	45

*Core Courses

Semester wise total minor and supporting courses of Department of Agronomy for Ph.D. programme

Subject Code	Subject Title	Credit Hours
	Semester-I	
PPHY-511	Physiological aspects for Mineral Nutrition	3(2+1)
STAT-531	Data Analysis Using Statistical Packages	3(2+1)
SCHEM-611	Advances in soil fertility	3(2+1)
	Semester-II	
SCHEM-521	Soil biology and biochemistry	3(2+1)
PPHY-622	Seed physiology	3(2+1)
STAT-521	Experimental Designs	3(2+1)

*Courses will be offered to the students as per the availability of faculty

Semester wise total non-credit courses of Department of Agronomy for Ph.D. programme

Subject Code	Subject Title	Credit Hours
	Semester-I	
PGS-501**	Library & information services	1 (0+1)
PGS-502**	Technical writing and communication skills	1 (0+1)
	Semester-II	
PGS-503**	Intellectual property and Its management in agriculture	1 (1+0)
PGS-504**	Basic concepts in Laboratory techniques	1 (0+1)
	Semester-III	
PGS-505**	Agricultural research, research Ethics and rural development programme (e-Course)	1 (1+0)
PGS-506**	Disaster Management	1 (1+0)

AGRON-611: ADVANCES IN CROP GROWTH AND PRODUCTIVITY 3(2+1)

Theory

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

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

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

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

Practical

1. Field measurement of root-shoot relationship in crops at different growth stages
2. Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
3. Computation of harvest index of various crops
4. Assessment of crop yield on the basis of yield attributing characters
5. Construction of crop growth curves based on growth analysis data
6. Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
7. Senescence and abscission indices
8. Analysis of productivity trend in un-irrigated areas
9. Analysis of productivity trend in irrigated areas

AGRON-612: ADVANCES IN WEED MANAGEMENT 3(2+1)

Theory

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

UNIT II: Important herbicide families & molecules; herbicide absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

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

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

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

UNIT VI: Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical herbicide bioassays.

Practical

1. **Identification of important weeds of different crops**
2. **Weed survey in crops and cropping systems (Relative density, frequency, abundance and economic importance)**
3. **Crop-weed competition in different cropping situations**
4. **Use of various types of spray pumps and nozzles and calculation of swath width**
5. **Preparation of spray solutions of herbicides for high and low-volume sprayers**
6. **Calculation of herbicide requirement**
7. **Residue management of herbicides,**
8. **Herbicide resistance analysis in plant and soil**
9. **Herbicide bioassays**
10. **Economics of weed control**

Note: Written in bold showed addition of topic(s) in the course

AGRON-613: IRRIGATION MANAGEMENT 3(2+1)

Theory

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

UNIT II: Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, scheduling of irrigation in field crops..

UNIT III: Measurement of irrigation water; Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

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

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

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

Practical

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

AGRON-614: CROP ECOLOGY 3(3+0)

Theory

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

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

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

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

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

AGRON-621: CURRENT TRENDS IN AGRONOMY 3(3+0)

Theory

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

UNIT II: Globalization of agriculture and WTO, precision agriculture, contract arming, organic farming, marketing and export potential of organic poducts, certification, labeling and accreditation procedures.

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

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

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

AGRON-622: STRESS CROP PRODUCTION 3(2+1)

Theory

UNIT I: Stress and strain terminology; nature and stress injury and resistance; causes of stress.

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

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

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

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

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

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

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

Practical

1. Determination of electrical conductivity of plant cell sap
2. Determination of osmotic potential and tissue water potential
3. Measurement of transpiration rate
4. Measurement of stomatal frequency
5. Growing of plants in sand culture under salt stress for biochemical and physiological studies
6. Studies on effect of osmotic and ionic stress on seed germination and seedling growth
7. Measurement of low temperature injury under field conditions

AGRON-623: INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE 3(3+0)

Theory

UNIT I: Farming systems: definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II: Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III: Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.

UNIT IV: Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.

UNIT V: New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

AGRON-624: CROP PRODUCTION AND SYSTEM MODELING 3(2+1)

Theory

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

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

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

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

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

Practical

1. Simulation of elementary models for crop growth
2. Simulation of potential production
3. Simulation with limitations of water and nutrient management options
4. Sensitivity analysis using different climatic years and crop management practices

MINOR & SUPPORTING COURSES

PPHY-511-PHYSIOLOGICAL ASPECTS OF MINERAL NUTRITION 3(2+1)

Theory

Overview of essential mineral elements. Nutrient uptake by root cell and their transport and movement in developing grain. Molecular mechanism of ion uptake, transport and their functional regulation. Molecular physiology of micronutrients acquisition. Strategies plants adopt to acquire and transport minerals under deficit level. Physiological and molecular mechanisms: underlying differential nutrients efficiency in crop genotypes. Breeding crop-variety for improved nutrients efficiency. Plants response to mineral toxicity,

Practical

1. Physiological and biological changes in plants under nutrients sufficiency and deficiency level.
2. Quantification of pigment level. Enzyme activities.

PPHY-622: SEED PHYSIOLOGY 3(2+1)

Theory

Seed and fruit development, abortion, proximate mechanism of abortion. Hereditary and environmental effects on seed development. Importance of seed, seed structure and function, physiological and biochemical changes during seed and fruit development and abortion. Seed storage: resources and sources of assimilation for seed development. Pathway of movement of assimilates in developing grains of monocots, chemical composition of seed, storage of carbohydrates, proteins and fats in seed and their biosynthesis. Seed respiration, mitochondrial activity, seed ageing, mobilization of stored food, oxidation 0f starch, protein and fats, and utilization of breakdown products by embryonic axis. Seed viability, seed vigour, seed dormancy, types and regulation, means to overcome seed dormancy.

Practical

1. Determination of seed protein
2. Alpha-amylase activity in germinating seeds.
3. Role of GA in inducing alpha-amylase activity, protease, and lipase activity in germinating seed.
4. Seed viability test and accelerated ageing test.

SCHEM-521: SOIL BIOLOGY AND BIOCHEMISTRY 3(2+1)

Theory

UNIT I: Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II: Microbiology and biochemistry of root-soil interface; phyllosphere and rhizosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV: Biodegradation of organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V: Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI: Biofertilizers: definition, classification, specifications, method of production and role in crop production. BIS standards for quality control.

Practical

1. Determination of soil microbial population
2. Soil microbial biomass (C, N and P)
3. Fractionation of organic matter and functional groups
4. Soil enzymes
5. Measurement of soil microbial processes such as nitrification, N2 fixation, S oxidation, P solubilization

SCHEM-611: ADVANCES IN SOIL FERTILITY 3(2+1)

Theory

UNIT I: Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II: Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III: Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV: Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V: Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI: Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Practicals

1. Determination of Q/I relationship of Phosphorus.
2. Determination of Q/I relationship of Potassium.
3. Determination of root cation exchange capacity of cereals and legumes.
4. Study of mobility of nutrient P and metallic cations in soil column.
5. Incubation studies on the solubilization of rock phosphate using chemical and biological agents.
6. Determination of phosphate potential in soil.

STAT-521 DESIGN OF EXPERIMENTS-I 3(2+1)

Theory

Basic principles of design of experiments, Uniformity trials and their uses, Fair field Smiths Variance Law and optimum size and shape of plots. Efficiency of basic designs. Factorial experiments: Symmetrical and Asymmetrical factorial experiments, 2^n factorial experiments, Yates method and general method of analysis of A x B and A x B x C factorial experiments. Confounding in case of 2^n factorial experiments, Complete and partial confounding. Layout and analysis of Split and Strip plot design. Missing plot technique in R.B.D. and L.S.D. with one observation missing. Progeny Row trial and compact family block design. Transformations: Square root, Logarithmic and Angular transformation. Analysis of Covariance.

Practicals

Analysis of 2^2 and 2^3 experiments in R.B.D., Analysis of AxB factorial experiments. Analysis of A x B x C factorial experiments, Complete confounding in case of 2^3 experiments, Partial confounding in case of 2^3 experiments, Missing plot analysis in case of R.B.D. with one observation missing, Missing plot analysis in case of L.S.D. with one observation missing. Analysis of Split plot and Strip plot design, Analysis of Covariance in case of R.B.D. Use of transformations

STAT-531: Data Analysis Using Statistical Packages 3(2+1)

Theory

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis, 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, 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, Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression, 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 display and table format and means for different sub- classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pair wise comparisons; Multiway classified analysis of variance - 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, Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals