



**Department of Agricultural Botany**  
**Mahatma Phule Krishi Vidyapeeth, Rahuri**  
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**Master's Programme**  
**in**  
**Plant Physiology**

**Course Layout**

**Minimum Credit Requirements**

Sr. No.	Subject	Minimum credit(s)
1.	Major	20
2.	Minor	09
3.	Supporting	05
4.	Seminar	01
5.	Research	20
	<b>Total Credits</b>	<b>55</b>
	Compulsory Non Credit Courses	06

Sr. No.	Course Number	Course Title	Credits
<b>A) Major subjects (Min. 20 credits)</b>			
1.	PP-501*	Principles of Plant Physiology	3+1=4
2.	PP -508*	Morphogenesis, Tissue Culture and Transformation	2+1=3
3.	PP-511	Mineral Nutrition	2+1=3
4.	PP-502*	Plant Developmental Biology, Physiological and Molecular Basis	2+0=2
5.	PP-503*	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1=3
6.	PP-504*	Hormonal Regulation of Plant Growth and Development	2+1=3
7.	PP -506*	Physiology of Growth, Yield and Modeling	1+1=2
<b>B) Minor Subjects (Min. 9 credits)</b>			
1	BIOCHEM-501	Basic Biochemistry	2+1=3
2.	AGRO-505	Agro Meteorology and Crop Weather Forecasting	2+1=3
3.	MBB-505	Techniques in Molecular Biology	0+3=3

<b>C) Supporting Subjects (Min. 5 credits)</b>			
1.	STAT-512	Experimental Design	2+1=3
2.	BIOCHEM-510	Carbon and Nitrogen Metabolism	2+1=3
<b>D) Seminar ( 1 credit)</b>			
1.	PP-591	Master Seminar	0+1=2
<b>E) Master's Research ( 20 credits)</b>			
1.		Master's Research	0+20=20
<b>F) Non Credit Compulsory Courses</b>			
1.	PGS-501	Library and Information Services	0+1=1
2.	PGS-504	Basic concepts in Laboratory techniques	0+1=1
3.	PGS-502	Technical Writing and Communication Skill	0+1=1
4.	PGS-503	Intellectual Property and Its Management in Agriculture	1+0=1
5.	PGS-505	Agriculture Research Ethics and Rural Development Programmes	1+0=1
6.	PGS-506	Disaster Management	1+0=1

**\*\* Compulsory course**

## Course Contents

### A)Major Subjects:

**Course No. : PP 501 PRINCIPLES OF PLANT PHYSIOLOGY Credit : 3+1=4**

#### Theory

Lecture No.	Topic to be covered
1-2	Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.
3-5	Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells.
6-7	Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorrhizal association on water uptake.
8-9	Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate.
10-11	Stomata structure and function – mechanism of stomatal movement, anti transpirants.
12-15	Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.
16-18	The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.
19-20	Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.
21-23	Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.
24-28	Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO <sub>2</sub> reduction in Calvin cycle, supplementary pathway of

	C fixation in C <sub>4</sub> and CAM plants and its significance.
29-32	Photorespiration and its relevance. Photosynthesis as a diffusive process-effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth.
33-35	Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.
36-38	Nitrogen metabolism: Inorganic nitrogen species (N <sub>2</sub> , NO <sub>3</sub> <sup>-</sup> and NH <sub>3</sub> ) and their reduction to aminoacids, protein synthesis and nucleic acids.
39-41	Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defense mechanism.
42-45	Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominanace, senescence, fruit growth, abscission.
46-48	Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

### Suggested Reading :

- 1.Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology* . John Wiley & Sons.
- 2.Salisbury FB & Ross C. 1992. *Plant Physiology*. 4 th Ed. Wadsworth Publ.
- 3.Taiz L & Zeiger E. 2006. *Plant Physiology* . 4th Ed. Sinauer Associates.

### PRACTICAL :

Exercise No.	Title of the exercise
1	Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe,
2	Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test.
3	Theory and principle of pressure bomb, psychrometer and osmometer,
4	Measurement of transpiration rate.
5	Measurement of vapour pressure deficits,
6	Theory and principle of porometry, diffusion prometer and Steady state porometer,
7	Stomatal physiology, influence of ABA on stomatal closing.
8	Mineral nutrients: Demonstration of energy requirement for ion uptake.
9	Deficiency symptoms of nutrients,
10	Radiant energy measurements,
11	Separation and quantification of chlorophylls,
12	O <sub>2</sub> evolution during photosynthesis,
13	Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates,
14	Estimation of reducing sugars, starch.
15	Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene.
16	Demonstration of photoperiodic response of plants in terms of flowering.

**Course No.: PP 502-PLANT DEVELOPMENTAL BIOLOGY :PHYSIOLOGICAL AND MOLECULAR BASIS . Credits : 2+0=2**

**Theory**

<b>Lecture No.</b>	<b>Topic to be covered</b>
1	Plant Biodiversity, Concept of evolution in plants.
2-3	General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analyzing plant growth.
4-6	Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.
7-11	Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.
12-15	Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.
16-18	Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.
19-20	Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.
21-24	Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants
25-27	Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants.
28-29	Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize.
30-31	Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants;
32	Self-incompatibility and its genetic control; Heterosis and apomixis.

**Course No. : PP 503- PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES . Credits : 2+1=3**

**Theory**

<b>Lecture No.</b>	<b>Topic to be covered</b>
1-4	Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.
5-7	Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept.
8-9	Transpiration and its regulation – stomatal functions.
10-14	Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and

	characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.
15-17	Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.
18-20	Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).
21-23	High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's.
24-26	Chilling stress: Effects on physiological processes. Crucial role of membrane lipids.
27-29	Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance.
30-32	Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

### Suggested Reading :

- 1.Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology* . John Wiley & Sons.
- 2.Salisbury FB & Ross C. 1992. *Plant Physiology*. 4 Ed.Wadsworth Publ. th
- 3.Taiz L & Zeiger E. 2006. *Plant Physiology* . 4th Ed. Sinauer Associates

### PRACTICAL :

Exercise No.	Title of the exercise
1	Measurement of water status of plants,
2	Determination of osmotic potential by vapour pressure and freezing point depression,
3-4	Determination of soil water potential and content by psychrometry and other systems.
5	Stress imposition and quantification, Stress –stomatal conductance.
6	Canopy temperature as a reflection of transpiration and root activity
7	Water use –efficiency
8	Determination at whole plant and single leaf level,Root- shoot signals
9-10	ABA and cytokinin effect on stomatal behavior
11	Heat tolerance and membrane integrity
12	Sullivans heat tolerance test
13	chilling tolerance
14-15	Galactolipase and free fatty acid levels as biochemical markers for chilling damage
16	Cold induced inactivation of O <sub>2</sub> evolution of chloroplasts- as a screening technique for chilling tolerance.

**Course No.: PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT. Credits : 2+1=3**

**Theory**

Lecture No.	Topic to be covered
1-6	Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. triconanol, Phenols –polyamines, jasmonates, concept of death hormone.
7-12	Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberellins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.
13-15	Hormone mutants and transgenic plants in understanding role of hormones.
16-21	Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plantparts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.
22-27	Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.
28-32	Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

**Suggested Reading :**

- 1.Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology* . John Wiley & Sons.
- 2.Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
- 3.Taiz L & Zeiger E. 2006. *Plant Physiology* . 4th Ed. Sinauer Associates.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-3	Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay
4-5	Extraction of hormones from plant tissue
6-8	Auxins- bioassays- auxins effect onrooting of cuttings, abscission, apical dominance
9-10	Gibberellins- bioassays-GA effect on germination of dormant seeds
11-12	Cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence
13-14	ABA bioassays- estimation using immunoassay technique. ABA effect on somatal movement
15-16	Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

**Course No.: PP 506 -PHYSIOLOGY OF GROWTH, YIELD AND MODELING  
Credit : 1+1=2**

**Theory**

Lecture No.	Topic to be covered
1-2	Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation
3-5	Phenology- Growth stages, internal and external factors influencing flowering.

	Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.
6-7	Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.
8-10	Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index.
11-12	Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.
13	Plant ideotypes,
14-15	Simple physiological yield models- Duncan's, Monteith's, and Passioura's
16	Crop growth models-empirical models testing and yield prediction.

**Suggested Reading :**

1. Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants* . Scientific Publ.
2. Goudriaan J & Van Laar HH. 1995. *Modelling Potential Crop Growth Processes*. (Textbook with Exercises) Series: *Current Issues in Production Ecology*. Vol. II. Kluwer.
3. Hunt R. *Plant Growth Curve -The Fundamental Approach to Plant Growth Analysis* . Edward Arnold.
4. John H, Thornley M & Johnson IR. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology* . Blackburn Press.
5. J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007. *Functional-Structural Plant Modelling in Crop Production*. Vol. XXII. Springer.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-2	Plant sampling for leaf area and biomass estimation
3-7	Analysis of growth and yield parameters – LAD, NAR, CGR, LAI, LAR, SLA
8-9	Portioning efficiency HI
10-12	Measurement of light interception, light extinction coefficient
13-14	Energy utilization efficiency based energy intercepted
15-16	Realized, Computer applications in plant physiology, crop productivity and modeling.

**Course No.: PP 508 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION . Credit : 2+1=3**

**Theory**

Lecture No.	Topic to be covered
1-2	Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation.
3-5	The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.
6-13	Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country ( ovary and ovule culture , in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.

14-19	Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot – tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions).
20-27	Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical . Use of markers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids)
28-32	Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introduction to <i>A. tumefaciens</i> . Tumour formation on plants using <i>A. tumefaciens</i> (Monocots vs Dicots), Root – formation using <i>A.rhizogenes</i>

### Suggested Reading :

- 1.Bajaj YPS. (Ed.). 1991. *Biotechnology in Agriculture and Forestry* . Vol. XIV. Springer-Verlag.
- 2.Rajdan MK. 1993. *Plant Tissue Culture* . Oxford & IBH.

### PRACTICAL :

Exercise No.	Title of the exercise
1-4	<i>In vitro</i> culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes
5-8	Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethylene on callus induction, organogenesis
9-11	Somatic embryogenesis
12-14	Effect of growth conditions such as temperature and photoperiod on organogenesis
15-16	Single – cell suspension cultures

**Course No.: PP 511 - MINERAL NUTRITION. Credits : 2+1=3**

### Theory

Lecture No.	Topic to be covered
1-3	Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.
4-9	Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.
10-17	Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.
18-23	Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.
24-30	Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.
31-32	Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.



**Suggested Reading :**

1. Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition* . CRC
2. Epstein E. 2007. *Mineral Nutrition of Plants* . John Wiley & Sons.
3. Marschner H. 1995. *Mineral Nutrition of Higher Plants* . Academic Press.

**PRACTICAL :**

Exercise No.	Title of the exercise
<b>Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels</b>	
1 - 2	Media for plant nutrition : Soil, Sand & Solution Culture
3- 4	Determination of Essentiality of Mineral Elements
<b>Quantification of pigment levels, enzyme activities</b>	
5 - 6	Estimation of Chlorophyll content of leaves
7 - 8	Estimation of Anthocyanin
9 -10	Determination of Peroxidase enzyme activity
11 -12	Determination of Amylase enzyme activity
13 -14	Determination of in vitro Nitrate reductase activity from leaf tissues
15 -16	Determination of Nitrite reductase (NIR) activity from leaf tissues

**B)Minor Subjects:**

Course No. : **BIOCHEM 501 BASIC BIOCHEMISTRY Credits 2+1=3**

**Theory**

Lecture No.	Topics to be covered
1	Scope and importance of biochemistry in agriculture
2	Fundamental principles governing life
3	Structure of water, acid-base concept
4	Buffer and pH, hydrogen bonding, hydrophobic, electrostatic and van der Waals forces
5-6	Fundamentals of thermodynamic principles applicable to biological processes, bioenergetics
7	Classification, structure and functions of carbohydrates
8-9	Metabolism of carbohydrates
10	Electron transport chain and oxidative phosphorylation
11-12	Photosynthesis
13-14	Classification, structure and functions of lipids Metabolism of lipids
15-16	Classification, structure and functions of amino acids and proteins. Metabolism of proteins
17	Structure, biological functions and classification of vitamins
18	Enzyme classification, factors affecting on enzyme action
19-20	Mechanism of enzyme action
21	Regulation of enzyme activity
22-23	Hormones: animals, plants and insects
24	Structure and functions of nucleic acids
25-26	Metabolism of nucleic acids
27	DNA replication
28-29	DNA transcription

30-31	Translation
32	Recombinant DNA technology

**Suggested Readings:**

- 1.Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.
- 2.Metzler DE. 2006. *Biochemistry*. Vols. I, II. Wiley International.
- 3.Nelson DL & Cox MM. 2004. *Lehninger Principles of Biochemistry*. 4<sup>th</sup> Ed. MacMillan.
- 4.Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. JohnWiley.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-2	Preparation of standard and buffer solutions
3	Estimation of reducing sugars by Nelson-somogyi method
4	Estimation of free amino acids by ninhydrin method
5-6	Estimation of protein by Lowry et al. (1951) method
7-9	Isolation of DNA and its quantification
10	Estimation of ascorbic acid
11-12	Isolation of RNA and its quantification
13-14	Separation of amino acid by TLC
15-16	Separation of amino acids by paper chromatography

**Course No. : AGRON 505 - AGROMETEOROLOGY AND CROP WEATHER FORECASTING. Credit : 2+1= 3**

**Theory**

Lecture No.	Topics to be covered
1-2	Agro meteorology – History , aim, scope and development in relation to crop environment
3-4	Composition of atmosphere
5	Distribution of atmospheric pressure and wind
6	Characteristics of solar radiation
7-8	Energy balance of atmosphere system; radiation distribution in plant canopies
9-11	Radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops
12	Energy budget of plant canopies
13-14	Environmental temperature: soil, air and canopy temperature
15-16	Temperature profile in air, soil, crop canopies
17-18	Soil and air temperature effects on plant processes; environmental moisture and evaporation:
19	Evapo-transpiration and meteorological factors determining evapo-transpiration
20-22	Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading
23	Protection from cold, sensible and latent heat flux, controlling soil moisture
24-25	Monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon
26	Weather hazards, drought monitoring and planning for mitigation
27-28	Weather forecasting in India- short, medium and long range
29	Aerospace science and weather forecasting; benefits of weather services to agriculture

30	Remote sensing; application in agriculture and its present status in India
31	Atmospheric pollution and its effect on climate and crop production
32	Climate change and its impact on agriculture

**Suggested Readings :**

- 1.Chang Jan Hu. 1968. Climate and Agriculture on Ecological Survey. Aldine Publ.
- 2.Critchfield HJ. 1995. General Climatology. Prentice Hall of India.
- 3.Das PK. 1968. The Monsoons. National Book Trust Publ.
- 4.Lal DS. 1998. Climatology. Sharda Pustak Bhawan.
- 5.Lenka D. 1998. Climate, Weather and Crops in India. Kalyani.
- 6.Mavi H.S. 1994. Introduction to Agro-meteorology. Oxford & IBH.
- 7.Mavi HS & Tupper GJ. 2004. Agrometeorology: Principles and Application of Climate Studies in Agriculture. Haworth Press.
- 8.Menon PA. 1991. Our Weather. National Book Trust Publ.
- 9.Sahu DD. Agrometeorology and Remote Sensing: Principles and Practices Agrobios.
- 10.Variraju R & Krishnamurty. 1995. Practical Manual on Agricultural
- 11.Meteorology. KalyaniVarshneya MC & Balakrishana Pillai P. 2003. Textbook of Agricultural Meteorology. ICAR.

**PRACTICAL :**

Exercise No.	Title of the exercise
1 -2	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.
3	Measurement of solar radiation outside and within plant canopy
4	Measurement/estimation of evapo-transpiration by various methods
5	Measurement/estimation of soil water balance
6	Rainfall variability analysis.
7	Determination of heat-unit requirement for different crops
8	Measurement of crop canopy temperature
9	Measurement of crop canopy temperature
10-11	Measurement of soil temperatures at different depths
12-13	Remote sensing and familiarization with agro-advisory service bulletins
14-15	Study of synoptic charts and weather reports, working principle of automatic weather station
16	Visit to solar observatory

**Course No : MBB 505 - TECHNIQUES IN MOLECULAR BIOLOGY-I**

**Credits : 0+3 =3**

**PRACTICAL :**

Exercise No.	Title of the exercise
1	Good lab practices
2-3	Biochemical techniques: Preparation of buffers and reagents

4-5	Principle of centrifugation
6-7	Chromatographic techniques :Separation of biomolecules by Thin Layer Chromatography
8-9	Molecular weight determination by Gel Filtration Chromatography
10-11	Protein purification by Ion exchange Chromatography
12-13	Protein purification Affinity Chromatography
14	SDS PAGE
15-16	Growth of bacterial culture and preparation of growth curve
17-18	Isolation of plasmid DNA from bacteria
19	Agarose gel electrophoresis
20-21	Growth of lambda phage and isolation of phage DNA
22-23	Restriction digestion of plasmid and phage DNA
24-25	Isolation of high molecular weight DNA and analysis
26-28	Recombinant DNA construction
29-31	Transformation and selection of transformants
32-33	PCR and optimization of factors affecting PCR
34-35	Dot blot analysis
36-37	Southern hybridization
38-39	Northern hybridization
40-42	Western blotting
43-45	ELISA
46-47	Radiation safety and non-radio isotopic procedure

### Suggested Readings :

1. Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. John Wiley.
2. Kun L Y. 2006. *Microbial Biotechnology*. World Scientific.
3. Sambrook J, Russell DW & Maniatis T. 2001. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbour Laboratory Press.

### C) Supporting Subjects:

Course No. : STAT-512 - EXPERIMENTAL DESIGN Credits : 2 + 1

#### Theory

Lecture No.	Topics to be covered
1	Need for design of experiment : definition, experiment, type experiment, field experiment of
2	Uniformity trials.
3	Basic Principles : Replication, randomization and local contro
4-5	Practical considerations : Deciding no. of replication, randomization of treatment, use of random number table, Local control, need of local control, size, shape of plots uses.
6-7	Concept of Analysis of Variance, Mathematical model, assumptions, random component, Practical consideration of one way and two way classification for field experiments.
8-9	C.R.D. : Definition, model, method of randomization for treatment and analysis, It's merits, demerits and application.

10-11	R. B.D. : Definition, model , method of randomization for treatment and analysis, It's merits, demerits and application.
12	Missing plot technique in RBD (one observation)
13	Orthogonal contrast and partitioning of degrees of freedom and sum of squares
14	L.S.D. : Definition, model, method of randomization for treatment and analysis, It's merits, demerits and application
15	Missing plot technique in LSD (one observation)
16-17	Factorial experiment : One factor, two factor and more than two factor experiment , level of factor, definition of simple, main and interaction effect.
18-19	Symmetrical, Asymmetrical factorial experiment $2^2$ , $2^3$ --- $2^n$ expt. general method of analysis.
20	Yates method of analysis in $2^n$ .
21	Concept of confounding in factorial experiment.
22	Factorial experiments with additional (Control) treatments.
23	Fitting of quadratic equation, economic optimization.
24-25	Split plot design : Layout, analysis and application.
26-27	Strip plot : Layout, analysis and application
28	Data transformation : Arcsine, Square root, Log.
29	Analysis of covariance in RBD
30	Concept of multi observational data, Method of taking data by <i>sampling plot techniques</i> .
31-32	Analysis of multi observational data.

### Suggested Readings:

1. Panse V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers. III Edition, - I.C.A.R, New Delhi.
2. Cochran, W.G. and Cox. G.M. 1957. Experimental Designs. II Edition, John Wiley and Sons, Inc. New York.
3. Snedecor G.W. and Cochran, W.G. 1967. Statistical Methods. VI Edition, Oxford & IBH Publishing Company, Bombay.
4. Gomez K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. II Edition, John Wiley and Sons, New York (International Rice Research Institute, Phillipines).
5. Nigam A.K. and Gupta, V.K. 1979. Handbook on Analysis of Agricultural Experiments. I Edition, Indian Agril. Statistics Research Institute, New Delhi.
6. Das M.N. and Giri, N.C. 1986. Design & Analysis of Experiments. II Edition, Wiley Reastern Ltd., New Delhi.
7. Kempthorne, Oskar 1952. The Design and Analysis of Experiments. I Edition, John Wiley and Sons, Inc. London.

### PRACTICAL :

Exercise No.	Title of the exercise
1-2	C.R.D. with equal and unequal replications.
3	R.B.D.
4	Orthogonal contrast and partitioning of degrees of freedom and sum of squares (RBD)
5	Missing plot in R.B.D.
6	. L.S.D.
7	$2^2$ , $2^3$ (Two - way table).

8	$2^2$ , $2^3$ (Yate's Method).
9	Asymmetrical factorial experiments (two factor).
10	Fitting of linear and quadratic curve for optimum dose.
11	Split plot experiments.
12	Strip plot.
13	Asymmetrical factorial experiments (two factors).
14	Asymmetrical factorial experiments (three factors).
15	Analysis of covariance in R.B.D.
16	Transformation of data in R.B.D

**Course No. : BIOCHEM 510 - CARBON AND NITROGEN METABOLISM**

**Credits: 2+1=3**

**Theory**

Lecture No.	Topics to be covered
1-2	Interdependence of carbon and nitrogen metabolism in plants
3-4	Biosynthesis of sucrose and its regulation in plant
5-6	Transport of sucrose, phloem loading and unloading, sink source relationship
7-10	Synthesis of starch in leaves and seed and concept of transitory starch. Regulation of starch synthesis
11-12	Synthesis of fructose, galactomannans, raffinose series of oligosaccharides
13-18	Nitrogen cycle, nitrate assimilation, regulation and interdependence on carbon metabolism
19-21	Mitochondrial metabolism in relation to carbon and nitrogen assimilation
22-23	Significance of alternative respiration and photorespiration in plant metabolism under global climate change
24	Chemoautotrophy in denitrifying bacteria
25-27	Biological nitrogen fixation : structure, function and regulation of nitrogenase
28-29	nif genes and their regulation
30-32	Legume –Rhizobium symbiosis

**Suggested Readings :**

1. Beever L. 1979. *Nitrogen Metabolism in Plants*. Gulab Vazirani for Arnold-Heinermann.
2. Bergersen FJ. (Ed.). 1980. *Methods for Evaluating Biological Nitrogen Fixation*. John Wiley & Sons. 38
3. Bray CM. 1983. *Nitrogen Metabolism in Plants*. Longman.
4. Buchanan BB, Gruissem W & James RL. (Eds.). 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists.
5. Mehta SL, Lodha ML & Sane PV. (Eds.). 1993. *Recent Advances in Plant Biochemistry*. ICAR.
6. Thimmaiah SK, 1999. *Standard Methods of Biochemical Analysis*, Kalyani Publication, New Delhi

**PRACTICAL :**

Exercise No	Title of the exercise
1	Estimation of nitrite content by diazotization reaction from the given sample
2	Estimation of proteins by Lowry et al. (1951) method

3	Estimation of starch by anthrone method
4	Estimation of nitrate content by hydrazine sulphate reduction method
5	<i>In vivo</i> assay of nitrate reductase from plant tissues
6-7	<i>In vitro</i> assay of nitrate reductase from plant tissues
8	<i>In vitro</i> assay of nitrite reductase from plant tissues
9	<i>In vitro</i> assay of glutamine synthetase from plant tissues
10	<i>In vitro</i> assay of glutamate synthase from plant tissues
11	<i>In vitro</i> assay of glutamate dehydrogenase from plant tissues
12-13	Estimation of allantoin and allantoic acid from legumes
14	Determination of asparagine synthetase activity from plant tissues
15	Assay of nitrogenase activity by acetylene reduction method by GLC
16	Estimation of hydrogen evolution by legume nodules

### D)Seminar

### E)Doctoral Research

### F) Compulsory Non Credit Courses

Course No. : PGS 501 -LIBRARY AND INFORMATION SERVICES

Credits : 0+1=1

#### PRACTICAL :

Exercise No.	Title of the exercise
1-2	Introduction to library and its services; types of library.
3	Role of libraries in education, research and technology transfer;
4	Classification systems and organization of library;
5-6	Sources of information- Primary sources, secondary sources and tertiary sources;
7-9	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABs reference sources;
10	Literature survey;
11	Citation techniques/Preparation of bibliography;
12	Use of CD-ROM Databases,
13	Online Public Access Catalogue and other computerized library services;
14-15	Use of Internet including search engines and its resources;
16	e-resources access methods.

Course No. : PGS 502 - TECHNICAL WRITING AND COMMUNICATIONS SKILLS Credits : 0+1=1

#### PRACTICAL :

Exercise No.	Title of the exercise
1	Various forms of scientific writings- theses, technical papers, reviews, manuals, etc;
2	Various parts of thesis and research communications (title page, authorship, contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);

3	Writing of abstracts, summaries, précis, citations etc.;
4	Commonly used abbreviations in the theses and research communications;
5	Illustrations, photographs and drawings with suitable captions;
6	Pagination, numbering of tables and illustrations;
7	Writing of numbers and dates in scientific write-ups;
8	Editing and proof-reading;
9	Writing of a review article.
10-11	Grammar (Tenses, parts of speech, clauses, punctuation marks);
12	Error analysis (Common errors);
13	Concord; Collocation; Phonetic symbols and transcription; Accentual pattern:
14	Weak forms in connected speech:
15	Participation in group discussion: Facing an interview;
16	Presentation of scientific papers.

### Suggested Readings :

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

**Course No. : PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT  
IN AGRICULTURE Credits : 1+0=1**

### Theory

Lecture No.	Topics to be covered
1-2	Historical perspectives and need for the introduction of Intellectual Property Right regime
3-4	TRIPs and various provisions in TRIPs Agreement
5	Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs
6	Indian Legislations for the protection of various types of Intellectual Properties
7-9	Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection
10-11	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection



12	National biodiversity protection initiatives
13	Convention on biological diversity
14-15	International Treaty on Plant Genetic Resources for Food and Agriculture
16	Licensing of technologies, Material transfer agreements, Research Collaboration Agreement, License Agreement

**Suggested Readings :**

1. Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V.
4. Technology Generation and IPR Issues. Academic Foundation. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
5. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
6. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

**Course No. : PGS 504 -BASIC CONCEPTS IN LABORATORY TECHNIQUES**

**Credits : 0+1=1**

**PRACTICAL :**

Exerc. No.	Title of the exercise
1	Safety measures while in Lab;
2	Handling of chemical substances;
3	Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
4	washing, drying and sterilization of glassware;
5	Drying of solvents/chemicals.
6	Weighing and preparation of solutions of different strengths and their dilution;
7	Handling techniques of solutions;
8	Preparation of different agro-chemical doses in field and pot applications;
9	Preparation of solutions of acids;
10	Neutralization of acid and bases;
11	Preparation of buffers of different strengths and pH values.
12	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
13	Electric wiring and earthlings.
14	Preparation of media and methods of sterilization;
15	Seed viability testing, testing of pollen viability;
16	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.
2. Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

**Course No. : PGS 505 -AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES. Credits : 1+0=1**

**Theory**

Lecture No.	Topics to be covered
1	History of agriculture in brief;
2	Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment;
3	National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions;
4	Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS,
5	role as a partner in the global agricultural research system, strengthening capacities at national and regional levels;
6	International fellowships for scientific mobility.
7	Research ethics: research integrity, research safety in laboratories,
8	Welfare of animals used in research,
9	Computer ethics,
10	Standards and problems in research ethics.
11	Concept and connotations of rural development,
12-13	rural development policies and strategies.
14	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, and Voluntary Agencies/Non R Governmental Organizations.
15	Critical evaluation of rural development policies and programmes.
16	Constraints in implementation of rural policies and programmes.

**Suggested Readings :**

1. Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.

**Course No. : PGS 506- DISASTER MANAGEMENT. Credits : 1+0=1**

**Theory**

Lecture No.	Topics to be covered
1-3	To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards and risks vulnerability; and capacity building.
4-5	Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches,

	Volcanic eruptions, Heat and cold waves
6-7	Climatic Change: Global warming, Sea level rise, Ozone depletion
8-10	Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents
11-12	Disaster Management- Efforts to mitigate natural disasters at national and global levels.
13-14	International Strategy for Disaster reduction.
15-16	Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

**Suggested Readings :**

1. Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Blackswan.
2. Hodgkinson PE & Stewart M. 1991. Coping with Catastrophe: A Handbook of Disaster Management. Routledge.
3. Sharma VK. 2001. Disaster Management. National Centre for Disaster Management, India.