



**Department of Agricultural Botany**  
**Mahatma Phule Krishi Vidyapeeth, Rahuri**  
**Tal. Rahuri 413 722, Dist. Ahmednagar (MS)**



**Master's Programme**  
*in*  
**Seed Science and Technology**

**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.	SST-501*	Floral Biology, Seed Development and Maturation	1+1=2
2.	SST-506*	Seed Legislation and Certification	2+1=3
3.	SST-509	Seed Physiology	2+1=3
4.	SST-502*	Principles of Seed Production	2+0=2
5.	SST-503*	Seed Production in Field Crops	2+1=3
6.	SST-507*	Seed Processing and Storage	2+1=3
7.	SST-508*	Seed Quality Testing	2+1=3
8.	SST-515	Emerging Trends in Seed Quality Enhancement.	1+1=2
<b>B) Minor Subjects (Min. 9 credits)</b>			
1	PP-501	Principles of Plant Physiology	3+1=4
2.	BIOCHEM-501	Basic Biochemistry	2+1=3
3.	PL.PATH-510	Seed Health Technology	2+1=3

<b>C) Supporting Subjects (Min. 5 credits)</b>			
1.	MBB-501	Principles of Biotechnology	2+1=3
2.	Stat-512	Experimental Design	2+1=3
<b>D) Seminar ( 1 credit)</b>			
1.	SST-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:**

**Syllabus of Theory and practical with suggested Readings/Books**

**Course No : SST 501- FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION . Credit : 1+1 =2**

#### **Theory**

<b>Lecture No.</b>	<b>Topics to be covered</b>
1	Floral types, structure and biology in relation to pollination mechanisms;
2	Sporogenesis: microsporogenesis and megasporogenesis
3	Gametogenesis development of male and female gametes and their structures
4	Effect of environmental factors on floral biology.
5 - 7	Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.
8	Embryogenesis - development of typical monocot and dicot embryos
9	Endosperm development, modification of food storage structures with reference to crop plants;
10	Different types of embryos, endosperm and cotyledons
11	Development and their structure in representative crop plants with reference to food storage;
12	External and internal features of monocot and dicot seed;
13	Seed coat structure and development in representative crop plants.
14	Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production
15	Polyembryony - types and significance; haplontic and diplontic sterility
16	Causes of embryo abortion, embryo rescue and synthetic seeds.

**Suggested Reading :**

1. Bhojwani SS & Bhatnagar SP. 1999. *The Embryology of Angiosperm*. Vikas Publ.
2. Black M, Bewley D & Halmer P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses*.
3. CABI. Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Deptt. of Plant Breeding, CCS HAU, Hisar. Copeland LO & McDonald MB. 2001. *Principles of Seed Science and Technology*. 4 Ed. Chapman & Hall.
4. The Frankel R & Galun E. 1977. *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag.

#### PRACTICAL :

Exercise No.	Title of the exercise
1-4	Study of floral biology of monocots and dicots, microsporogenesis and megasporogenesis
5-8	Study of pollen grains - pollen morphology, pollen germination and pollen sterility
9-11	Types monocot and dicot embryos
12-14	External and internal structures of monocot and dicot seeds
15-16	Seed coat structure, preparation of seed albums and identification.

**Course No. : SST 502- PRINCIPLES OF SEED PRODUCTION Credits : 2+0=2**

#### Theory

Lecture No.	Topics to be covered
1	Seed as basic input in agriculture; seed development in cultivated plants;
2-3	Seed quality concept and importance of genetic purity in seed production;
4-5	Types of cultivars, their maintenance and factors responsible for deterioration;
6	Seed production in self and cross pollinated crops
7-8	Mode of pollination and reproduction in crop plants and their modification in relation to hybrid seed production..
9	Principles of hybrid seed production, isolation distance, synchronization of flowering, rouging etc.
10-11	Male sterility and incompatibility system in hybrid seed production, role of pollinators and their management
12	Seed multiplication ratios, seed replacement rate, demand and supply;
13-14	Suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production;
15-17	Generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved;
18-20	Life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops.
21,22	Hybrid Seed - Methods of development of hybrids; use of male sterility.
23	Self-incompatibility and CHA in hybrid seed production;
24-25	One, two and three line system; maintenance of parental lines of hybrids;
26-27	Planning and management of hybrid seed production technology of major field crops and vegetables.
28,29	Planning of seed production for different classes of seeds for self and cross-pollinated crops,
30-31	Seed quality control system and organization, seed village concept;.
32	Seed production agencies, seed industry and custom seed production in India

**Suggested Reading :**

1. Agarwal RL. 1997. *Seed Technology* . 2 nd Ed. Oxford & IBH.
2. Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Dept. of Plant Breeding CCS HAU, Hisar. Desai BB. 2004. *Seeds Handbook* .
3. Marcel Dekker. Kelly AF. 1988. *Seed Production of Agricultural Crops* . Longman.
4. McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices* .
5. Chapman & Hall. Musil AF. 1967. *Identification of Crop and Weed Seeds* . Handbook No. 219, USDA, Washington, DC, USA.
6. Poehlman JM & Sleper DA. 2006. *Breeding Field Crops* . Blackwell.
7. Singh BD. 2005. *Plant Breeding: Principles and Methods*.
8. Kalyani. Singhal NC. 2003. *Hybrid Seed Production in Field Crops* . Kalyani.
9. Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.
10. Tunwar NS & Singh SV. 1985. *Handbook of Cultivars* . CSCB, GOI.

**Course No. : SST 503 SEED PRODUCTION IN FIELD CROPS Credits : 2+1=3**

## Theory

Lecture No.	Topics to be covered
1-2	Basic principles in seed production and importance of quality seed.
3-6	Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.
7-10	Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc
11-13	Methods and techniques of quality seed production in cross-pollinated cereals and millets.
14-18	Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green gram, black gram, field beans, peas etc.).
19-26	Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).
27-32	Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

**Suggested Reading :**

1. Kelly AF. 1988. *Seed Production of Agricultural Crops* . John Wiley.
2. McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices* . Chapman & Hall.
3. Singhal NC. 2003. *Hybrid Seed Production in Field Crops* . Kalyani.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-3	Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate;
4-6	Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines,
7-8	Synchronization of parental lines and methods to achieve synchrony; supplementary pollination,.

9-11	Pollen storage, hand emasculation and pollination in Cotton, detasseling in Corn,
12-14	Identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity;
15-16	Gametocide application and visits to seed production plots etc

**Course No. : SST 506 - SEED LEGISLATION AND CERTIFICATION Credits : 2+1=3**

**Theory**

Lecture No.	Topics to be covered
1-2	Historical development of Seed Industry in India;
3-5	Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling.
6-7	Seed quality control- concept and objectives; Central Seed Certification Board (CSCB).
8-9	Regulatory mechanisms of seed quality control- organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control;
10-13	Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004.
14-15	Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India.
16-18	Seed Certification- history, concept and objectives of seed certification; seed certification agency/organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards
19-20	Indian Minimum Seed Certification Standards (I.M.S.C.S.)- general and specific crop standards including GM varieties, field and seed standards
21-23	Planning and management of seed certification programmes- eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc.
24	Field Inspection- principles, phases and procedures; reporting and evaluation of observations
25	Pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate;
26-27	Types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes
28	Introduction to WTO and IPR and TRIPS agreement. Related to agriculture
29-31	Plant Variety Protection act 2001 and its significance, DUS testing- principles and applications; essential features of PPV & FR Act, 2001 and related Acts.
32	UPOV: History methods of protections, plant breeder's right and role of UPO.

**Suggested Reading :**

1. Agarwal RL. 1997. Seed Technology. Oxford & IBH.
2. The protection of Plant varieties and farmers right Act 2001- Universal law publishing co. Delhi
3. General guide lines for examination of Distinctness, Uniformity and stability and harmonized descriptions of varieties : PPV and FR Authority New Delhi

4. Anonymous 1992. *Legislation on Seeds*. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.
5. Nema NP. 1986. *Principles of Seed Certification and Testing*. Allied Publs.
6. Tunwar NS & Singh SN. 1988. *Indian Minimum Seed Certification Standards*. CSCB, Ministry of Agriculture, New Delhi.
7. Anonymous 1992. *Legislation on Seeds*. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi

**PRACTICAL :**

<b>Exercise No.</b>	<b>Title of the exercise</b>
1	Study of general procedure of seed certification
2	Identification of weed and other crop seeds as per specific crops;
3-4	field inspection at different stages of a crop and observations recorded on contaminants and reporting of results
5	Inspection and sampling at harvesting/threshing, processing and after processing for seed law enforcement
6	Determination of physical purity of seed sample
7	Determination of germination percentage of seed sample
8	Determination of moisture content of seed sample
9	To study the specifications for tags and labels to be used for certification purpose
10	To study the methods of conducting grow-out tests for pre and post-harvest quality control
11	grow-out tests for pre and post-harvest quality control
12	Visit to regulatory seed testing laboratory(STL) and study the working of STL
13-14	Visit to plant quarantine laboratory and study its working
15-16	Visit to seed certification agency office and study the procedure of seed certification

**Course No. : SST 507**

**SEED PROCESSING AND STORAGE**

**Credit : 2+1=3**

**Theory**

<b>Lecture No.</b>	<b>Topics to be covered</b>
1	Introduction: Principles of seed processing
2 -4	Methods of seed drying including dehumidification and its impact on seed quality
5-6	Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage
7-8	Loss of viability in important agricultural and horticultural crops
9	Viability equations and application of nomograph
10-12	Principles of seed cleaning and methods of seed cleaning, Seed cleaning equipment and their functions
13-15	Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader
16-17	Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines
18	Seed blending
19	Assembly line of processing and storage, receiving, elevating and conveying equipments
20-21	Plant design and layout, requirements and economic feasibility of seed processing plant

22-23	Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfection, identification of treated seeds
24	Packaging: principles, practices and materials; bagging and labeling
25	Seed storage: Seed drying and storage; drying methods-importance and factors affecting it
26-27	Changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content
28-29	Methods to minimize the loss of seed vigour and viability; factors influencing storage losses
30-31	Storage methods and godown sanitation. Storage structures
32	Storage problems of recalcitrant seeds and their conservation

#### Suggested Reading :

1. Agrawal RL. 1996. *Seed Technology* . Oxford Publ.
2. Barton LV. 1985. *Seed Preservation and Longevity* . International Books and Periodicals Supply Service, New Delhi.
3. Hall CW. 1966. *Drying of Farms Crops* . Lyall Book Depot.
4. Justice OL & Bass LN. 1978. *Principles and Practices of Seed Storage* Castle House Publ.
5. Mathews RK, Welch GB, Delouche JC & Dougherty GM. 1969. *Drying, Processing and Storage of Corn seed in Tropical and Subtropical Regions*. Proc. Am. Agric. Eng. St. Joseph, Mich. Paper No. 69-67.
6. Sahay KM & Singh K K. 1991. Unit Operations in Food Engineering. Vikas Publ.
7. Viridi SS & Gregg BG. 1970. *Principles of Seed Processing* . National Seed Corp., New Delhi

#### PRACTICAL :

Exercise No.	Title of the exercise
1-2	Operation and handling of mechanical drying equipments
3-5	Effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds
6	Seed extraction methods
7	Seed processing equipments
8	Seed treating equipments
9-10	Visit to seed processing plant and commercial controlled and uncontrolled Seed Stores
11-12	Seed quality upgradation, Seed blending, Bag closures
13	Measurement of processing efficiency
14	Study of orthodox, intermediary and recalcitrant seeds
15	Evaluating seed viability at different RH and temperature levels and packaging materials
16	Prediction of storability by accelerated ageing controlled deterioration tests

**Course No. : SST 508 SEED QUALITY TESTING Credit : 2+1=3**

#### Theory

Lecture No.	Topics to be covered
1	Introduction: Structure of monocot and dicot seeds
2,3	Seed quality: objectives, concept and components and their role in seed quality control
4	Instruments, devices and tools used in seed testing
5	ISTA and its role in seed testing

6,7	Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity
8	Methods of preparing composite and submitted samples; sub-sampling techniques
9	Dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory
10-11	Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria
12	Pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results
13	Prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram
14	Determination of other distinguishable varieties (ODV); determination of test weight and application of heterogeneity test
15-16	Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation- types, instruments and devices used.
17	Pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results
18	Germination: importance; definitions; requirements for germination, instrument and substrata required
19	Principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method
20	Duration of test; seedling evaluation; calculation and reporting of results
21	Dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy
22	Viability and Vigour Testing: definition and importance of viability tests; different viability tests
23	Quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results
24	Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour
25	Genetic purity testing : objective and criteria for genetic purity testing; types of test; laboratory, Growth Chamber and field testing based on seed , seedling and mature plant morphology
26	Principles and procedures of chemical, biochemical and molecular tests
27	Seed health Testing: field and seed standards
28	Designated diseases, objectionable weeds - significance of seed borne disease vis-à-vis
29	Seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes
30	Testing of GM seeds and trait purity, load of detection (LOD).
31	Preparation and dispatch of seed testing reports
32	Storage of guard samples; application and use of seed standards and tolerances

#### **Suggested Reading :**

1. Agarwal RL. 1997. *Seed Technology* . Oxford & IBH.
2. Agrawal PK & Dadlani M.1992. *Techniques in Seed Science and Technology* . 2 Ed. South Asian Publ. nd
3. Agrawal PK. (Ed.). 1993. *Handbook of Seed Testing* . Ministry of Agriculture, GOI, New Delhi.
4. Copland LO & McDonald MB. 1996 .*Principles of Seed Science and Technology* . Kluwer.



5. ISTA 2006. *Seed Testing Manual*. ISTA, Switzerland.
6. Martin C & Barkley D. 1961. *Seed Identification Manual*. Oxford & IBH.
7. Tunwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards* Central Seed Certification Board, Ministry of Agriculture, New Delhi.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-2	Structure of monocot and dicot seeds of important plant species
3	Identification and handling of instruments used in seed testing laboratory
4	Identification of seeds of weeds and crops; physical purity analysis of samples of different crops
5	Estimation of seed moisture content (oven method)
6-7	Seed dormancy breaking methods
8-10	Requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agri-horticultural crops; seedling evaluation
11	Viability testing by tetrazolium test in different crops
12	Seed and seedling vigour tests applicable in various crops; species
13	Cultivar identification; genetic purity testing by chemical and biochemical
14	Cultivar identification; genetic purity testing by molecular methods
15	Seed health testing for designated diseases, blotter methods, agar method and embryo count methods
16	Testing coated/pelleted seeds.

**Course No. : SST 509 - SEED PHYSIOLOGY. Credits : 2+1=3**

Theory

Lecture No.	Topics to be covered
1-2	Physiology of seed development and maturation
3-4	Chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance
5-6	Hormonal regulation of seed development.
7-8	Seed germination; factors affecting germination
9-11	Role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination
12-13	Seed respiration, breakdown of stored reserves in seeds, mobilization and inter-conversion pathways
14-15	Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy
16-17	Role of phytochrome and PGR, genetic control of dormancy.
18-20	Seed viability and longevity, pre and post-harvest factors affecting seed viability
21-23	Seed ageing ; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability
24-25	Mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.
26-28	Seed vigour and its concept, vigour test methods, factors affecting seed vigour,
29-30	Physiological basis of seed vigour in relation to crop performance and yield.
31-32	Seed invigoration and its physiological and molecular control

**Suggested Reading :**

1. Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*.

South Asian Publ.

2. Baskin CC & Baskin JM. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination* . Academic Press.
3. Basra AS. 2006. *Handbook of Seed Science and Technology* . Food Product Press.
4. Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology* . Food Product Press.
5. Bewley JD & Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination* . Vols. I, II. Springer Verlag.
6. Bewley JD & Black M. 1985. *Seed: Physiology of Seed Development and Germination* . Plenum Press.
7. Copeland LO & Mc Donald MB. 1995. *Principles of Seed Science and Technology* . 3 Ed. Chapman & Hall. rd
8. Khan AA. 1977. *Physiology and Biochemistry of Seed Dormancy and Germination* . North Holland Co.
9. Kigel J & Galili G. (Eds.). *Seed Development and Germination* . Marcel Dekker.
10. Murray DR. 1984. *Seed Physiology*. Vols. I, II. Academic Press. Sadasivam S & Manickam A. 1996. *Biochemical Methods* . 2 Ed.

**PRACTICAL :**

Exercise No.	Title of the exercise
1	To study of proximate analysis of chemical composition of seed
2	To study of different methods of testing viability
3-4	To study the kinetics of seed imbibition and solute leakage
5	To determine the solute leakage with the help of EC/ pH meter
6-7	To demonstrate the effect of temperature and moisture on seed germination
8-9	To demonstrate the different methods of dormancy breaking
10	To study different seed invigoration and priming treatments
11-12	To study the accelerated ageing and controlled deterioration tests
13-14	To study the enzymatic activities and determination of respiration during germination and calculation of R.Q.
15	To study the effect of accelerated ageing on seed viability
16	To study the different vigour testing methods etc.

**Course No. : SST-515 EMERGING TRENDS IN SEED QUALITY ENHANCEMENT**

**Credits : 1 +1 =2**

**Theory**

Lecture No.	Topics to be covered
1	Concept and significance of seed quality enhancement;
2	Physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology
3	Factors affecting seed enhancement treatments.
4	Seed priming: physiological and biochemical basis
5-7	Types of priming technology, biochemical and molecular changes associated, pregermiantion, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.
8-9	film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming
10-11	Synthetic seeds – Aim and scope for synthetic seeds, historical development,
12-13	Somatic embryogenesis, somaclonal variation and their control

14	Embryo encapsulation systems, hardening of artificial seeds
15-16	Cryo-preservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

### Suggested Reading :

1. Basra AS. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications* . Food Product Press, NY.
2. Basra AS. 2006. *Handbook of Seed Science and Technology* . Food Product. Press, NY
3. Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology* . Food Product Press, NY/ London.
4. Copland LO & McDonald MB. 2004. *Seed Science and Technology. Kluwer Acad. Perspective* . Associated Publishing Company, New Delhi.
5. Kalloo G, Jain SK, Vari AK & Srivastava U. 2006. *Seed: A Global*

### PRACTICAL :

Exercise No.	Title of the exercise
1	Seed treatments – methods and techniques, equipments required for seed treatment
2	Demonstration of film coating of seed
3-4	Demonstration of seed invigoration/priming - hydration and dehydration
5-6	Demonstration of PEG priming, solid matrix priming
7	Demonstration of solid matrix priming
8-9	Demonstration of bio priming and its effects of priming
10-11	Demonstration of methods for hydrogel encapsulation of artificial endosperm,
12-13	Demonstration of methods hydrophobic coating of seed
14-15	Study of protocols for production of synthetic seeds
16	Visit to leading Seed Companies to study the seed treatment processes.

### B)Minor 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 dominance, 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 porometer 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.
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**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. : PL. PATH 510 - Seed Health Technology .Credit : 2+1=3**

**Theory**

Lecture No.	Topic to be covered
1 - 2	Seed Pathology – Introduction, terminology and history
3	Economic significant of seed borne diseases.
4-5	Plant quarantine and SPS under WTO
6 - 7	Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds
8 - 9	Types of microorganisms associated with seeds and diseases caused by them.
10 - 11	Locations of seed borne inoculums and Mechanisms seed infection.
12	Factors affecting the seed infection
13	Longevity of seed borne pathogens.
14	Factors affecting the Longevity of seed borne pathogens.
15 - 16	Mechanisms of seed transmission.
17	Factors affecting the seed transmission
18 - 19	Epidemiological factors influencing the transmission of seed borne diseases.
20 - 21	Forecasting of epidemics through seed borne infection.
22 - 23	Seed certification and tolerance limit
24	Types of losses caused by seed borne diseases in true and vegetatively propagated seeds
25	Evolutionary adaptations of crop plants to defined seed invasion by seed borne pathogens.
26 - 27	Deterioration of seeds by storage fungi, production of toxic metabolites affecting seed quality and its impact on human, animal and plant health.
28 - 30	Management of seed borne Pathogens/diseases and procedure for healthy seed production.
31 -32	Seed health testing methods for detecting microorganisms.

**Suggested Readings :**

1. Agarwal. V.K & J.B Sinclair. 1993. Principles of Seed Pathology. Vols. I & II, CBS Publ., New Delhi.
2. Hutchins J.D & Reeves J.E. (Eds.). 1997. Seed Health Testing: Progress Towards the 21<sup>st</sup> Century. CABI, Wallington.
3. Paul Neergaard. 1988. Seed Pathology. MacMillan, London
4. .Suryanarayana D. 1978. Seed Pathology. Vikash Publ., New Delhi.

**PRACTICAL :**

Exercise No.	Title of the exercise
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1 & 2	<b>Study of commonly occurring seed - borne fungi.</b> <i>Alternaria, Curvularia, Drechslera, Fusarium, Collectotrichum, Phoma, Macrophomina, Aspergillus, Rhizopus, Penicillium.</i>
3	<b>Methods of examination of seed borne fungi.</b> a) Visual and microscopic examination of dry seed. b) Seed washing test.
4	<b>Incubation methods.</b> a) Detection of seed borne fungi by blotter method
5	b) Detection of seed borne fungi by agar plate method c) Detection of seed borne fungi by freezing method d) Detection of seed borne fungi by 2-4 D method e) Detection of internal seed borne fungi by component plating method
6	Detection of embryo borne ( <i>Ustilago nuda tritici</i> ) loose smut of Wheat by Embryo count method.
7	<b>Study or seedling symptom test</b> a) Test tube plain agar method b) Hiltner's bricks stone method c) Sand method d) Standard soil method.
8	<b>Detection of seed borne bacteria</b> a) Water agar plate method. b) Quartz sand method
9	<b>Detection of seed borne viruses</b> a) Examination of dry seed sample Growing on test
10-16	<b>Detection of externally and internally seed borne pathogens by nucleic acid based techniques</b> a) RFLP, PCR, Serological techniques like ELISA

### C) Supporting subjects

Course No : MBB 501 - PRINCIPLES OF BIOTECHNOLOGY Credits : 2+1 =3

#### Theory

Lecture No.	Topics to be Covered
1-2	History, scope and importance;
	DNA structure, function and metabolism.
3-4	DNA modifying enzymes and vectors;
5-6	Methods of recombinant DNA technology;
7-8	Nucleic acid hybridization;
9-10	Gene libraries;
11-12	PCR amplification;
13-14	Plant and animal cell and tissue culture techniques and their applications.
15-17	Molecular markers and their applications;

18-19	DNA sequencing;
20-22	Applications of gene cloning in basic and applied research;
23-24	Genetic engineering and transgenics;
25-28	Genomics, transcriptomics and proteomics.
29	General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics

30	Public perception of biotechnology;
31	Bio-safety and bioethics issues;
32	Intellectual property rights in biotechnology.

**Suggested Readings :**

1. Becker JM, Coldwell GA & Zachgo EA. 2007. *Biotechnology – a Laboratory Course*. Academic Press.
2. Brown CM, Campbell I & Priest FG. 2005. *Introduction to Biotechnology*. Panima Pub.
3. Brown TA. *Gene Cloning and DNA Analysis*. 5th Ed. Blackwell Publishing.
4. Dale JW & von Schantz M. 2002. *From Genes to Genomes: Concepts and Applications of DNA Technology*. John Wiley & Sons.
5. Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publications.
6. Sambrook J, Fritsch T & Maniatis T. 2001. *Molecular Cloning – a Laboratory Manual*. 2nd Ed. Cold Spring Harbour Laboratory Press.
7. Singh BD. 2007. *Biotechnology Expanding Horiozon*. Kalyani Publishers.

**PRACTICAL :**

Exercise No.	Title of the exercise
1-2	Isolation of genomic and plasmid DNA
3	Gel electrophoresis techniques
4-8	Restriction enzyme digestion, ligation, transformation and screening- of transformants
9-12	PCR and molecular marker analysis
13-16	Plant tissue culture: media preparation, cell and explants culture, regeneration and transformation.

**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 : Arcsign, 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.Kemphorne, 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

## 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.
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**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
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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	Rrural 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.
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**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 Managem