RAMAKRISHNA MISSION VIVEKANANDA EDUCATIONAL & RESEARCH INSTITUTE

(Declared by Government of India under section 3 of UGC Act, 1956)

P.O. Belur Math, District- Howrah, West Bengal: 711202

INTEGRATED RURAL DEVELOPMENT & MANAGEMENT (IRDM) FACULTY CENTRE

at

Ramakrishna Mission Ashrama, Narendrapur, Kolkata: 700 103

M.Sc. (Ag.) in 'Genetics and Plant Breeding'

PROPOSED COURSE CONTENT

(w.e.f. 2023-2024 session)

Semester-I

Code	Title of the Course	Credits
GPB 501	Principles of Genetics	2+1+1=4
GPB 502	Principles of Plant Breeding	2+0+1=3
GPB 505	Principles of Cytogenetics	2+0+1=3
GPB 511	Crop Breeding-I (*Kharif* Crops)	2+0+1=3
CBT 101	Molecular Biology	3+0+0=3
SCH 101	Spiritual and Cultural Heritage of India-I	2+0+0=2
PGS 503	Intellectual Property and its Management in Agriculture (e-Course)	1+0+0=1
PGS 504	Basic Concepts in Laboratory Techniques	0+0+1=1
	TOTAL	14+1+5=20

Semester-II

Code	Title of the Course	Credits
GPB 503	Fundamentals of Quantitative Genetics	2+1+1=4
GPB 512	Crop Breeding-II (Rabi Crops)	2+0+1=3
GPB 523	Basic Design of Experiment	2+0+1=3
GPB 525	Plant Tissue Culture	1+0+2=3
CBT 201	Genetic Engineering	3+0+0=3
CBT 206	Laboratory-IV: Genetic Engineering	0+0+3=3
SCH 201	Spiritual and Cultural Heritage of India-II	2+0+0=2
	TOTAL	12+1+8=21

Semester-III

Code	Title of the Course	Credits
GPB 506	Molecular Breeding and Bioinformatics	2+1+1=4
GPB 516	Breeding for Stress Resistance and Climate Change	2+0+1=3
GPB 518	Plant Genetic Resources and their Utilization	1+0+1=2

GPB 524	Analytical Techniques & Instrumental Methods in Soil & Plant Analysis	0+0+2=2
GPB 591	Seminar-I	0+0+1=1
PGS 501	Library and Information Services	0+0+1=1
PGS 502	Technical Writing and Communication Skills	0+0+1=1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes (e-course)	1+0+0=1
SCH 301	Human Values and Professional Ethics	1+0+1=2
	Recommended Electives (Optional)	3*
	TOTAL	7+1+6=20*

Recommended Electives (Semester-III)

Code	Title of the Course	Credits
GPB 507	Breeding for Quality and Special Traits	2+0+1=3
GPB 508	Mutagenesis and Mutation Breeding	2+0+1=3
GPB 509	Hybrid Breeding	2+0+1=3
GPB 510	Seed Production and Certification	2+0+1=3
GPB 520	Breeding Horticultural Crops	2+0+1=3

Semester-IV

Code	Title of the Course	Credits
GPB 592	Seminar-II	0+0+1=1
GPB 599	Project Work	0+0+20=20
	TOTAL	0+0+21=21

Course Structure at a Glance

Core Courses (CC):

Code	Title of the Course	Credits
GPB 501	Principles of Genetics	2+1+1=4
GPB 502	Principles of Plant Breeding	2+0+1=3
GPB 505	Principles of Cytogenetics	2+0+1=3
GPB 510	Seed Production and Certification	2+0+1=3
GPB 512	Crop Breeding-II (Rabi Crops)	2+0+1=3
GPB 518	Plant Genetic Resources and their Utilization	1+0+1=2
GPB 503	Fundamentals of Quantitative Genetics	2+1+1=4
GPB 509	Hybrid Breeding	2+0+1=3
GPB 511	Crop Breeding-I (*Kharif* Crops)	2+0+1=3
GPB 523	Basic Design of Experiment	2+0+1=3
GPB 525	Plant Tissue Culture	1+0+2=3
GPB 506	Molecular Breeding and Bioinformatics	2+1+1=4
GPB 508	Mutagenesis and Mutation Breeding	2+0+1=3
GPB 516	Breeding for Stress Resistance and Climate Change	2+0+1=3

Discipline Specific Elective (DSE) Courses:

Code	Title of the Course	Credits
GPB 507	Breeding for Quality and Special Traits	2+0+1=3
GPB 520	Breeding Horticultural Crops	2+0+1=3

Generic Elective (GE) Courses [Compulsory]:

Code	Title of the Course	Credits
CBT 101	Fundamentals of Molecular Biology	3+0+0=3
CBT 201	Genetic Engineering	3+0+0=3
CBT 206	Laboratory-IV: Genetic Engineering	0+0+3=3

Ability Enhancement Compulsory Courses (AECC):

Code	Title of the Course	Credits
PGS 502	Technical Writing and Communication Skills	0+0+1=1

Skill Enhancement Courses (SEC) [Compulsory]:

Code	Title of the Course	Credits
SCH 101	Spiritual and Cultural Heritage of India-I	2+0+0=2
SCH 201	Spiritual and Cultural Heritage of India-II	2+0+0=2
SCH 301	Human Values and Professional Ethics	1+0+1=2
PGS 501	Library and Information Services	0+0+1=1
PGS 503	Intellectual Property and its management in Agriculture	1+0+0=1
PGS 504	Basic Concepts in Laboratory Techniques	0+0+1=1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes (e-course)	1+0+0=1
GPB 524	Analytical Techniques & Instrumental Methods in Soil & Plant Analysis	0+0+2=2
GPB 591	Seminar-I	0+0+1=1
GPB 592	Seminar-II	0+0+1=1
GPB 599	Project Work	0+0+20=20

M.Sc. (Ag.) in Genetics and Plant Breeding

Total Credits: 20 **First Semester** **Total 360Hrs.**

GPB 501 Principles of Genetics (2+1+1=4) credits 72 Hrs.

About this Course…

Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.

Course Objective:

This course is aimed at understanding the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Course Learning Outcome:

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Theory: 2 Credits /36 Hours

UNIT I

Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT II

Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

UNIT III

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

UNIT IV

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection;DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

UNIT V

Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

Practical: 1 Credit/18 Hours

1. Laboratory exercises in probability and chi-square;
2. Demonstration of genetic principles using laboratory organisms;
3. Chromosome mapping using three-point test cross;
4. Tetrad analysis; Induction and detection of mutations through genetic tests;
5. DNA extraction and PCR amplification;
6. Electrophoresis: basic principles and running of amplified DNA;
7. Extraction of proteins and isozymes;
8. Use of Agrobacterium mediated method and Biolistic gun;
9. Detection of transgenes in the exposed plant material;
10. Visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings:

1. Daniel LH and Maryellen R. 2011. Genetics: “Analysis of Genes and Genomes”.
2. Gardner EJ and Snustad DP. 1991. Principles of Genetics. John Wiley and Sons. 8th ed. 2006
3. Klug WS and Cummings MR. 2003. Concepts of Genetics. Peterson Edu. Pearson Education India; Tenth edition
4. Lewin B. 2008. Genes XII. Jones and Bartlett Publ. (International Edition) Paperback, 2018
5. Russell PJ. 1998. Genetics. The Benzamin/ Cummings Publ. Co.
6. Singh BD. 2009. Genetics. Kalyani Publishers (2nd Revised Edition)
7. Snustad DP and Simmons MJ. 2006. Genetics. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition
8. Stansfield WD.1991. Genetics.Schaum Outline Series Mc Graw Hill
9. Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India; 3rd ed., 2015
10. Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs., McGraw Hill Education; 7 edition
11. Uppal S, Yadav R, Singh S and Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

GPB 502 Principles of Plant Breeding (2+0+1=3) credits 54 Hrs.

About this course…

Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour.

Course Objective:

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Course Learning Outcome:

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, etc.

Theory: 2 Credits /36 Hours

UNIT I

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

UNIT II

Genetic basis of breeding: self- and cross-pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

UNIT III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

UNIT IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and

their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

UNIT V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

UNIT VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

UNIT VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical: 1 Credit /18 Hours

1. Floral biology in self- and cross-pollinated species;
2. Selfing and crossing techniques;
3. Selection methods in segregating populations and evaluation of breeding material;
4. Analysis of variance (ANOVA);
5. Estimation of heritability and genetic advance;
6. Maintenance of experimental records;
7. Learning techniques in hybrid seed production using male-sterility in field crops;
8. Prediction of performance of double cross hybrid.

Suggested Readings:

1. Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
2. Chahal GS and Gossal, SS. 2002. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House.
3. Chopra VL. 2004. Plant Breeding. Oxford & IBH.
4. George A. 2012. Principles of Plant Genetics and Breeding. John Wiley & Sons.
5. Gupta SK. 2005. Practical Plant Breeding. Agribios.
6. Jain HK and Kharakwal MC. 2004. Plant Breeding and–Mendelian to Molecular Approach, Narosa Publications, New Delhi
7. Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
8. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
9. Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.
10. Simmonds NW.1990. Principles of Crop Improvement. English Language Book Society.
11. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
12. Singh S and Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

GPB 505 Principles of Cytogenetics (2+0+1=3) credits 54 Hrs.

About this Course…

The very purpose of this course is to acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes, special types of chromosomes, techniques for karyotyping. This course aims to impart knowledge of variations in chromosomes numbers and their structures. It acquaints the students for the production and use of haploids, apomictic populations and their role in genetics and breeding.

Course Objective:

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Course Learning Outcome:

The course will provide full knowledge to the student on the various procedures linked with cell development and chromosome structure and function. This course will also enable student how to tailor and utilize the variation in chromosome number and structures in the development and synthesis of new species and varieties.

Theory: 2 Credits /36 Hours

UNIT I

Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting –In situ hybridization and various applications.

UNIT II

Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

UNIT III

Fertilization barriers in crop plants at pre-and postfertilization levels; In-vitro techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

UNIT IV

Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, Triticale, Brassica, and cotton); Hybrids between species

with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

UNIT V

Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical: 1 Credit/18 Hours

1. Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.
2. Microscopy: various types of microscopes.
3. Preparing specimen for observation.
4. Fixative preparation and fixing specimen for light microscopy studies in cereals.
5. Studies on mitosis and meiosis in crop plants.
6. Using micrometres and studying the pollen grain size in various crops. Pollen germination *in vivo* and *in-vitro*.
7. Demonstration of polyploidy.

Suggested Readings:

1. Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson Edu. 9th edition.
2. Carroll M. 1989. *Organelles*. The Guilford Press.
3. Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.
4. Darlington CD and La Cour LF. 1969. *The Handling of Chromosomes*. George Allen & Unwin Ltd.
5. Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRLPress,Oxford.
6. Gupta PK and Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A.
7. Gupta PK. 2010. *Cytogenetics*. Rastogi Pubishers.
8. Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.
9. Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons.
10. Khush GS. 1973. *Cytogenetics of aneuploids*. Elsevier. 1 edition.
11. Roy D.2009. *Cytogenetics*. Alpha Science Intl Ltd.
12. Schulz SJ.1980. *Cytogenetics- Plant, animals and Humans*. Springer.
13. Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth- Heinemann publisher 2014.3rd edition
14. Singh RJ. 2016. Plant *Cytogenetics* 3rd Edition. CRC Press.
15. Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub.
16. Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

GPB 511 Crop Breeding-I (*Kharif* Crops) (2+0+1=3) credits 54 Hrs.

About this Course…

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Kharif field crops.

Course Objective:

To provide insight into recent advances in improvement of kharif cereals, legumes, oilseeds, fibre, sugarcane and vegetative propagated crops using conventional and modern biotechnological approaches.

Course Learning Outcome:

After completing this course, the student will be able to know about important botanical status and reproductive structures of crops and genetics of important kharif field crops.

Theory: 2 Credits /36 Hours

UNIT I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.

Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

UNIT II

Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.*;* Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding,
released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Urdbean, mungbean, cowpea: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality

characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT III

Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Castor and Sesame: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), released varieties, examples of MAS
used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements.

UNIT IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding,released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

UNIT V

Sugarcane: Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, etc.

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc.

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Achievements of important spice crops.

Practical: 1 Credit /18 Hours

1. Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton
2. Study of range of variation for yield and yield components
3. Study of segregating populations in cereal, pulses and oilseed crops
4. Learning on the crosses between different species; attempting crosses between black gram and green gram
5. Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;
6. Visit to Cotton Technology Laboratory and Spinning Mills;
7. Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;
8. Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability;
9. Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;
10. Visit to animal feed producing factories;
11. Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

Suggested Readings:

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.Pulses and Oilseeds. Oxford & IBH.
3. Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.
4. Chopra VL and Prakash S. 2002. Evolution and Adaptation of Cereal Crops. Oxford & IBH.
5. Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
6. IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier.
7. IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
8. IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.IRRI.
9. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
10. IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
11. Jennings PR, Coffman WR and Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.
12. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and
13. Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU,Coimbatore.
14. Murty DS, Tabo R and Ajayi O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India.
15. Nanda JS. 1997. Manual on Rice Breeding. Kalyani Publishers. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural Crops Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
16. Poehlman, JM. 1987. Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut, USA.
17. Ram HH and Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
18. Sharma, AK. 2005. Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner
19. Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.

20. Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
21. Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

CBT 101 Molecular Biology (3+0+0=3) credits 54Hrs.

About this Course…

The course "Fundamentals of Molecular Biology" provides a comprehensive understanding of the basic concepts and principles of molecular biology. It aims to equip students with the fundamental knowledge and skills required to pursue a career in various fields related to molecular biology, such as genetics, biotechnology, and biochemistry.

Course Objective:

The objectives of this course are to make students understand how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information in prokaryotes and eukaryotic cells. Further, to appreciate the subject of molecular biology as a dynamic and ever-changing experimental science.

Course Learning Outcome:

Gain fundamental knowledge on molecular architecture of prokaryotic and eukaryotic genomes. Understand the various molecular events that lead to duplication of DNA, recombination of genes, transcription and translation following a central dogma. Understand molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes.

Theory: 3 Credits /54 Hours

UNIT I

Structure of DNA: A, B, Z and triplex DNA; Central dogma, DNA and RNA as genetic material; DNA contents and C-value paradox; melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA. RNA: Structure, and Function.

UNIT II

Replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle; DNA damaging agents: Physical, chemical and biological mutagens; types of damage caused by endogenous and exogenous agents; Mutations: nonsense, missense, silent and point mutations, frameshift mutations; Intragenic and Intergenic suppression. DNA repair mechanisms: direct reversal, photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, double strand break repair, SOS repair; Recombination: Chi sequences in prokaryotes; Homologous, non-homologous and site-specific recombination.

UNIT III

Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription: RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: lac, trp, his operons, attenuation, anti-termination, stringent control, translational control, DNA rearrangement, two component system; regulatory RNA: riboswitch, tmRNA, antisense RNA; transcriptional control in lambda phage.

UNIT IV

Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription: RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing, polyadenylation; mRNA stability and degradation: degradation and surveillance pathways; RNA editing; Nuclear export of mRNA; Catalytic RNA: Group I and Group II introns splicing, Peptidyl transferase; Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; Silencers and insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; C2H2 zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loophelix), nuclear receptors; Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors;

UNIT V

Nuclear Ribosomes; Composition and assembly; universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; Wobble hypothesis; Isoaccepting tRNA; Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins; Translational control; Protein stability; Protein turnover and degradation.

Suggested Readings:

1. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
3. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.

SCH 101 Spiritual and Cultural Heritage of India-I

(2+0+0=2) credits 36 Hrs.

About this Course…

This course is designed to introduce students to the spiritual and cultural heritage of India. It focuses on the teachings of Swami Vivekananda and Vedic hymns, as well as on India's past, present, and future. Through this course, students will gain a deeper understanding of India's cultural and spiritual traditions and their relevance in contemporary society.

Course Objective:

This course is designed to familiarize the students with Swami Vivekananda's comprehensive philosophy of education and its scope in its individual and social dimensions. The student will be exposed to the high ideals of education through selected teachings of Swami Vivekananda and guided to understand and approach their role as a citizen with the right attitude. The student would be given a clear picture of the challenges faced by the society and the effective method for addressing them. The course would cover in detail the idea of education in all its aspects– the effective method for acquiring knowledge, the way to apply education to solve the problems of an individual, and the role of education in addressing the short-term and long-term needs of the society.

Course Learning Outcome:

Embrace their role as a student and an individual-in the-making holding immense promise to the society. Understand the problems faced by the society/nation and the effective approach for solving them. Develop a comprehensive idea of education in all its aspects in light of Swami Vivekananda's teachings. Understand how to apply education to solve the challenges faced in life. Develop an understanding of the effective method of acquiring and transferring knowledge.

Theory: 2 Credits /36 Hours

1. Shanti Mantras and some selected Vedic hymns.
2. Life of Swami Vivekanada (Journey from Narendranath Datta to Swami Vivekananda) and his speech at Parliament of Religion.
3. Swami Vivekananda on India: India's eminence, Life centre, Mission and Future.
4. India's decadence: (a) Its Causes - We are to blame, Ignoring the past, Narrowing our outlook, Perversion of religion, Tyaranny over massesn Neglect of women.
   (b) It's symptoms and Cure – Cultural heresey and fanaticism, Physical weakness, Lack of faith in ourselves etc.
5. Essentials for Regeneration: Training Sincere Workers, Deluging the Land with Spiritual Ideals, Social Reform, Its Method.
6. Education the Pancea of all social evils: The present system, True Education, Ideal Method – Concentration and Detachment, Brahmacharya, Shraddha, Character, Communion with Nature, Gurukula system, Psychological approach, Presenent Need and Swami's Plan.

Suggested Readings:

1. Swami Tejasananda. (1995). *A Short Life of Swami Vivekananda*. Advaita Ashrama.
2. Swami Vivekananda. (2008). *My Idea of Education*. Advaita Ashrama.
3. Swami Vivekananda. (1918). *Lectures from Colombo to Almora*. Advaita Ashrama.

PGS 503 Intellectual Property And Its Management In Agriculture (1+0+0=1) credits 18 Hrs.

About this Course…

This course offers a comprehensive exploration of Intellectual Property Rights (IPR) and their significance in contemporary society. It delves into the historical context and rationale for the establishment of IPR regimes, focusing on the TRIPS Agreement. The course provides a thorough understanding of various types of intellectual properties, including patents, copyrights, trademarks, geographical indications, trade secrets, and more. It also covers Indian legislation related to IPR and global initiatives for the protection of biodiversity. Additionally, the course delves into licensing of technologies, material transfer agreements, research collaboration agreements, and license agreements in the realm of IPR.

Course Objective:

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

Course Learning Outcome:

By completing this course, students will be able to:

- Understand the historical evolution and importance of Intellectual Property Rights (IPR).
- Grasp the provisions of the TRIPS Agreement and its global impact.
- Differentiate between various types of Intellectual Property and their protective scope.
- Evaluate the benefits of securing Intellectual Property Rights.
- Analyze Indian legislation safeguarding different forms of Intellectual Properties.
- Comprehend the fundamentals of patents, copyrights, trademarks, and more.
- Assess ownership and protection duration in the realm of IPR.
- Recognize the significance of protecting traditional knowledge and biodiversity.
- Comprehend licensing processes and research collaboration agreements in IPR contexts.

Theory: 1 Credit /18 Hours

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings:

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

PGS 504 Basic Concepts in Laboratory Techniques (0+0+1=1) credits 18Hrs.

About this Course…

This course is designed to provide students with fundamental knowledge and skills required to safely and accurately perform laboratory techniques in the field of genetics and plant breeding. Laboratory techniques are essential for conducting research and development in genetics and plant breeding.

Course Objective:

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

Course Learning Outcome:

Students will learn how to perform laboratory methods such as handling chemicals, making solutions, and sterilising glassware in a safe and correct manner. They will also learn how to utilise laboratory equipment such as microscopes and viscometers, as well as how to assess seed and pollen viability. Students will have a solid foundation in laboratory procedures essential for genetics and plant breeding research by the end of the course.

Practical: 1 Credit /18 Hours

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. Neutralisation 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 earthing
14. Preparation of media and methods of sterilization
15. Seed viability testing, testing of pollen viability
16. Tissue culture of crop plants
17. 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.
3. Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
4. Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis.ELBS Longman.

Total Credits: 21 **Second Semester** **Total Hrs. 378**

GPB 503 Fundamentals of Quantitative Genetics (2+1+1=4) credits 72 Hrs.

About this Course…

Yield and quality characters are controlled by many genes and show the quantitative inheritance. If one has to go for improvement even for the components characters the knowledge of this course is very essential.

Course Objective:

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effects.

Course Learning Outcome:

After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

Theory: 2 Credits /36 Hours

UNIT I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

UNIT II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

UNIT III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D2, Generation mean analysis, Parent progeny regression analysis

UNIT IV

Mating designs- classification, Diallel, partial diallel, L × T, NCDs, and TTC;Concept of combining ability and gene action, G × E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis.

UNIT V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

Practical: 1 Credit/18 Hours

1. Analysis and interpretation of variability parameters.
2. Analysis and interpretation of Index score and Metroglyph.
3. Clustering and interpretation of D2 analysis
4. Genotypic and phenotypic correlation analysis and interpretation
5. Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation
6. A, B and C Scaling test
7. L × T analysis and interpretation, QTL analysis
8. Use of computer packages
9. Diallel analysis
10. G × E interaction and stability analysis.

Suggested Readings:

1. Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
2. Falconer DS and Mackay J. 1998. Introduction to Quantitative Genetics (3rd Ed.).ELBS/Longman, London.
3. Mather K and Jinks JL.1985. Biometrical Genetics (3rd Ed.). Chapman and Hall, London.
4. Nandarajan N and Gunasekaran M. 2008. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
5. Naryanan SS and Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
6. Roy D. 2000. Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House,New Delhi.
7. Sharma JR. 2006. Statistical and Biometrical Techniques in Plant Breeding. New Age International Pvt. Ltd.
8. Singh P and Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani Publishers, New Delhi.
9. Singh RK and Chaudhary BD. 1987. Biometrical Methods in Quantitative Genetic analysis. Kalyani Publishers, New Delhi.
10. Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
11. Wricke G and Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

e-Suggested Reading

www.iasri.icar.gov.in

www.hau.ac.in/OPstat

GPB 512 Crop Breeding-II (Rabi Crops) (2+0+1=3) credits 54 Hrs.

About this Course …

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Rabi field crops.

Course Objective:

To provide insight into recent advances in improvement of Rabi cereals, legumes oilseeds, fibre and vegetative propagated crops using conventional and modern biotechnological approaches

Course Learning Outcome:

After completion of this course the student will be able to know about the different breeding methods and genetics of major Rabi field crops.

Theory: 2 Credits /36 Hours

UNIT I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics –cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

UNIT II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Lentil, field pea, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT III

Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

UNIT IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

UNIT V

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

Practical: 1 Credit /18 Hours

1. Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower;
2. Study of range of variation for yield and yield components;
3. Study of segregating populations in cereal, pulses and oilseed crops;
4. Use of descriptors for cataloguing; Learning on the crosses between different species;

5. Trait based screening for stress resistance;
6. Learning on the Standard Evaluation System (SES) and descriptors;
7. Use of software for database management and retrieval.

Suggested Readings:

1. Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl PN and Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I.
3. Pulses and Oilseeds. Oxford & IBH.
4. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. I. Springer, USA.
5. Gupta SK. 2012. Technological Innovations in Major World Oil crops. Vol. II. Springer, USA.
6. Gupta SK. 2016. Breeding of Oilseed Crops for Sustainable Production. Academic Press, USA.
7. Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. New Dimensions and
8. Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU,Coimbatore.
9. Parthasarathy VA. 2017. Spices and Plantation Crops Vol.1 (Part A) Breeding of Breeding and
10. Genetics. John Wiley & Sons.

GPB 523 Basic Design of Experiment (2+0+1=3) credits 54 Hrs.

About this Course…

This course covers statistical methods for data analysis and experimental design.

Course Objective:

To impart knowledge of probability distributions, hypothesis testing, regression analysis, and experimental design principles.

Course Learning Outcome:

By the end of this course, students will be able to:

- Apply probability distributions in data analysis.
- Perform hypothesis tests using various distributions.
- Conduct correlation and regression analysis.
- Design and analyze experiments using different designs.
- Implement dimensionality reduction techniques.
- Apply statistical tools in practical scenarios, including fitting distributions and response surfaces.

Theory: 2 Credits /36 Hours

UNIT – I

Probability distributions: Binomial, Poisson, Negative binomial, Normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions.

UNIT – II

Theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model. Estimation of parameters. Predicted values and residuals. Correlation: Partial correlation coefficient, Multiple correlation coefficient, Rank correlation. Test of significance of correlation coefficient. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods. Confidence interval for sensitivity. Testing for heterogeneity.

UNIT – III

Selection of variables. Validation of models. Introduction to multivariate analytical tools. Principal component analysis.

UNIT – IV

Selection of variables. Validation of models. Introduction to multivariate analytical tools. Principal component analysis.

UNIT V

Basic principles of design of experiments. Uniformity trials. Analysis of variance. Completely randomized design, Randomized block design (RBD), Latin square design (LSD), Balanced incomplete block design, Resolvable block designs and their applications. Alpha design and Lattice design-concepts.

UNIT VI

Randomization procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD.

UNIT VII

Factorial experiments (symmetrical as well as asymmetrical). Confounding in factorial experiments - application in 2n and 3n factorial experiments. Factorial experiments with control treatment.

UNIT VIII

Groups of experiments. Split plot and Strip plot designs. Change-over design. Sampling in field experiments. Transformation of data. Response surfaces. Experiments with mixture.

Practical: 1 Credit /18 Hours

1. Exploratory data analysis, Box-Cox plots.
2. Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal.
3. Large sample tests, Testing of hypothesis based on exact sampling distributions ~ chi square, t and F. Confidence interval.
4. Estimation and point estimation of parameters of Binomial, Poisson and Normal distribution.
5. Correlation and regression analysis. Fitting of orthogonal polynomial regression.
6. Applications of dimensionality reduction and Discriminant function analysis. Non-parametric tests.

7. Uniformity trial data analysis.
8. Formation of plots and blocks.
9. Fairfield Smith Law.
10. Analysis of data obtained from CRD, RBD, LSD.
11. Analysis of Covariance.
12. Analysis of factorial experiments without and with confounding.
13. Analysis with missing data.
14. Split plot and strip plot designs.
15. Groups of experiments, Transformation of data.
16. Fitting of response surfaces.

Suggested Readings:

1. Anderson, T.W. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.
2. Campbell, R.A. 1974. Statistics for Biologists. Cambridge University Press.
3. Dillon, W.R. and Goldstein, M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.
4. Electronic Statistics Text Book:http://www.statsoft.com/textbook/stathome.html.
5. Goon, A.M., Gupta, M.K. and Dasgupta, B. 1977. An Outline of Statistical Theory. Vol. I. The World Press Pvt. Ltd., Calcutta.
6. Goon, A.M., Gupta, M.K. and Das Gupta, B. 1983. Fundamentals of Statistics.Vol. I. The World Press Pvt. Ltd., Calcutta.
7. Gupta, S.C. and Kapoor, V.K. 2007.Fundamentals of Mathematical Statistics.Sultan Chand and Sons.
8. Hoel, P.G. 1971. Introduction to Mathematical Statistics. John Wiley.Hogg, R.V. and Craig, T.T. 1978. Introduction to Mathematical Statistics.Macmillan.
9. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
10. Morrison, D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
11. Murray, R. 2000. Schaum's Outline of Theory and Problems of Probability and Statistics. McGraw Hill.
12. Siegel, S., Johan, N. and Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
13. Snedecor, G.W. and Cochran, W.G. 1936. Statistical Methods. Oxford.
14. Cochran, W.G. and Cox, G.M. 1957. Experimental Design. John Wiley and Sons Inc.
15. Das, M. N. and Giri, N.C. 1986. Design and Analysis of Experiments. New Age International.
16. Gomez and Gomez. 1984. Statistical procedure for Agricultural Research. Wiley-interscience.
17. Panse, V.G. and Sukhatme P.V. 1967. Statistical Method for Agricultural Workers. ICAR Publication.
18. Steel, H.G.D. and Torri, J.M. 1960. Principal and Procedure of Statistics. McGraw Hill, New York

GPB 525 Plant Tissue Culture (1+0+2=3) credits 54 Hrs.

About this Course…

Plant tissue culture is a powerful tool that can be used for plant propagation, genetic improvement, and production of secondary metabolites. This course provides students with a fundamental understanding of plant cell and tissue culture, its history, and its application in crop improvement. It also provides students with practical knowledge of the techniques and methods involved in tissue culture, including media preparation, sterilization techniques, and different types of cultures. The course will also cover the different applications of plant tissue culture, such as organogenesis, embryogenesis, somaclonal variation, and cryopreservation.

Course Objective:

The objective of this course is to deal with the principles, technical requirements, scientific and commercial applications of plant tissue culture. To expose to various supporting methodologies of plant tissue culture, micro propagation techniques and applications of plant tissue culture to crop improvement.

Course Learning Outcome:

Students understand the concepts and principles of plant tissue culture. Learning and monitoring different techniques of sterilization, different pathways of plant regeneration under in vitro conditions -organogenesis and somatic embryogenesis. They will understand the techniques of virus elimination- methods of virus indexing. Meristem and shoot tip culture and its applications. Culturing of reproductive structures-anther, microspores, embryos, endosperm, ovule and ovary cultures and methods to produce haploids.

Theory: 1 Credit /18 Hours

UNIT I

History of plant cell and tissue culture, Application of tissue culture in crop improvement, Culture media, Sterilization technique, Totipotency, types of culture, Micro propagation.

UNIT II

Organogenesis (direct and indirect), Embryogenesis (direct and indirect), Somaclonal and gametoclonal variation, somatic embryos and artificial seeds-Cryo preservation.

UNIT III

Meristem culture vis-à-vis virus elimination, Protoplast culture vis-à-vis wide hybridization, protoplast fusion, somatic hybrids, protoplast viability test, Embryo culture and embryo rescue, Anther culture vis-à-vis dihaploids, Cell suspension culture and secondary metabolites, hardening techniques.

Practical: 1 Credits /18 Hours

1. Laboratory setup; Sterilization of glass goods, plastic wares, media and plant materials
2. Formulation and preparation of media for shoot and root initiation.
3. Fresh Culture for micropropagation; Subculturing
4. Direct organogenesis using suitable explants.
5. Indirect organogenesis using suitable explants
6. Suspension culture development from calli; Somatic embryogenesis from calli.
7. Embryo culture, Anther culture; Preparation of competent cell.
8. Cloning of DNA.

Suggested Readings:

1. Bhojwani, S. S. (1990). Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam.
2. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
3. Singh, B. D. (2007). Biotechnology: Expanding Horizons. Kalyani Publishers.
4. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
5. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH:Science.

CBT 201 Genetic Engineering (3+0+0=3) credits 54 Hrs.

About this Course…

Genetic engineering and plant tissue culture are important subfields in biotechnology that have revolutionized our ability to manipulate and modify living organisms. These techniques have wide-ranging applications in medicine, agriculture, industry, and environmental conservation. Therefore, it is essential for students pursuing a degree in biotechnology to have a thorough understanding of these methods, their underlying principles, and their potential benefits and risks.

Course Objective:

The objectives of this course are to teach various approaches to genetic engineering that students can apply in their future career in biological research as well as in biotechnology industry. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course. This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

Course Learning Outcomes:

Endow themselves with strong theoretical knowledge of this technology, Gain working knowledge of gene silencing and editing tools and methods and appreciate their relevance for

investigating specific contemporary biological questions. Take up biological research as well as find placement in the relevant biotech industry.

Theory: 3 Credits /54 Hours

UNIT I

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric ailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far- western and colony hybridization, fluorescence in situ hybridization.

UNIT II

Plasmids; Bacteriophages; M13mp vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tagetc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

UNIT III

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR: multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; Mutation detection: SSCP, DGGE, RFLP.

UNIT IV

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and Total RNA; Reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays: genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions:electrophoretic mobility shift assay; DNase I foot printing; methyl interference assay, chromatin immune precipitation; protein-protein interactions using yeast two-hybrid system; phagedisplay.

Suggested Readings:

1. Brown, TA. (2006). Genomes (3rd ed.). New York: Garland Science Pub.

2. Old, R.W.; Primrose, S.B.; & Twyman, R.M.; (2001). Principles of Gene Manipulation: An Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
3. Green, MR., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

CBT 206 Laboratory-IV: Genetic Engineering (0+0+3=3) credits 54 Hrs.

About this Course …

The course of Molecular Biology and Genetic Engineering is included in the syllabus to provide students with a fundamental understanding of the genetic material, its manipulation, and applications in various fields. Molecular biology and genetic engineering are widely used in modern biotechnology, medical research, and drug development. The course covers topics such as DNA isolation, restriction enzymes, plasmid DNA isolation, agarose gel electrophoresis, PCR, and recombinant DNA technology. These techniques are essential in modern research and have significant applications in gene therapy, genetic diagnosis, and the production of therapeutic proteins.

Course Objective:

The objective of this laboratory course is to provide the students practical skills on basic molecular biology and genetic engineering techniques.

Course Learning Outcome:

Acquire basic molecular biology techniques and principles. Get first-hand experience that will coincide with what is taught in the lecture portion of the class. Gain hands-on experience in gene cloning, PCR amplification, protein expression and purification.

Practical: 3 Credits /54 Hours

1. Isolation of Genomic DNA from
a) E. coli (Bacteria)
b) Candida species (Fungus)
c) Banana (Plant)
d) Blood cells (Animal)
2. Plasmid DNA isolation and DNA quantitation
3. Restriction Enzyme digestion of plasmid DNA
4. Agarose gel electrophoresis
5. Polymerase chain reaction (PCR) and analysis by Agarose gel electrophoresis
6. Purification of DNA from Agarose gel
7. Vector and Insert ligation
8. Preparation of competent cells
9. Transformation of E. coli with standard plasmid, Calculation of Transformation efficiency
10. Confirmation of the Insert by Restriction mapping

11. SDS-PAGE gel electrophoresis
12. Expression of recombinant protein, concept of soluble proteins and inclusion bodies in E. coli.

Suggested readings:

1. Anolles, G. C. and Gresshoff, P.M., (1997), *DNA markers– Protocols, Applications and Overviews*. Wiley-Liss, New York.
2. Henry R. J., (2005), *Plant Genotyping: the DNA Fingerprinting of Plants*. CABI, New Delhi.
3. R.K. Varshney, R. Tuberosa, (2008). *Genomics Assisted Crop Improvement,* Springer.

SCH 201 Spiritual and Cultural Heritage of India-II

(2+0+0=2) credits 36Hrs.

About this Course …

The course on "Spiritual and Cultural Heritage of India-II" is included in the syllabus to provide students with an understanding of the spiritual and cultural values that have shaped India's history and society. The course emphasizes the teachings of the Srimad Bhagavad Gita and Swami Vivekananda's philosophy to provide students with an in-depth understanding of the spiritual and cultural heritage of India. The course aims to encourage students to develop a sense of cultural identity, respect for diversity, and an appreciation for India's spiritual heritage.

Course Objective:

This course is designed to impart to the student a comprehensive understanding of various social challenges faced by modern India and its way forward in light of Swami Vivekananda's insightful study of these subjects. The course would familiarize the student with Swami Vivekananda's ideas on women empowerment combining ancient ideals of womanhood with scope for adapting to the needs of the modern society. The importance of improving the condition of the poorer classes, an essential feature of an enlightened society, will be discussed in detail. The greater role that an enlightened India would play in the modern world and the blueprint for its harmonious and beneficent relationship with the rest of the world will be discussed.

Course Learning Outcome:

Chant selected Vedic hymns that bring the student in touch with the ideas of traditional Indian Knowledge. Understand the traditional Indian ideal of womanhood and the way to bring back a respectable position for women in the society compatible with both the ancient ideals and the modern needs. Recognize the importance of serving equally the whole society, especially the lower classes, and feel inspired to dedicate their knowledge and skills to this cause. Understand the great future role that India has to play in the world and her relationship with other nations involving both teaching and learning, to the mutual benefit of both.

Theory: 2 Credits /36 Hours

UNIT I

Selected Shlokas from Srimad Bhagavad Gita on shaping own destiny, secret of work and success, concentration of mind: Bhagavad Gita-6.5, Bhagavad Gita-6.6, Bhagavad Gita-2.3, Bhagavad Gita-2.47, Bhagavad Gita-2.48, Bhagavad Gita-6.38, Bhagavad Gita-6.35.

UNIT II

Swami Vivekananda's Message on the Uplift of the Masses: Dedicate yourself; develop faith in equality and oneness of man; educate the masses, solution to the caste problem.

UNIT III

Swami Vivekananda's view on caste problem and its solution: Caste is a social institution not a religious institution, Ideal of Brahmin-ness, Characteristics of noble-minded man, Untouchability is form of mental disease, Uplifting all to the state of ideal Brahminhood.

UNIT IV

Swami Vivekananda's Message on Women's Empowerment: The ideal of woman as mother; womanhood personified in Sita; as warrior; eligibility for the highest knowledge; common humanity grounds; respecting the women; all round education of women; develop their own solutions

UNIT V

Swami Vivekananda's Message on Restoring our National Glory: India's ideal is spirituality, India's mission is spiritual regeneration of the world, India's solution to life's challenges, India must share the spiritual knowledge with the West and gain material knowledge from them, India is readying for its time under the sun.

UNIT VI

Swami Vivekananda's thought on Karma Yoga: Karma in its effect on character is the most tremendous power that man has to deal with, what is duty, power of purity and chastity, How to make the duty sweeter in daily life.

Suggested Readings:

1. Swami Vivekananda. (1946). Swami Vivekananda on India and Her Problems. Compiled by Swami Nirvedananda.Advaita Ashrama.
2. Swami Vivekananda. (1918). Lectures from Colombo to Almora.Advaita Ashrama.
3. Swami Chidananda. (2013). Sankshipta Sasvara Veda Mantrah (Sanskrit). SriRamakrishna Ashrama.

Total Credits: 20 **Third Semester** **Total Hrs.360**

GPB 506 Molecular Breeding and Bioinformatics (2+1+1=4) credits 72 Hrs.

About this Course…

The course will provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining. This will also add ways to perform marker-assisted selection and gene pyramiding to evolve superior varieties.

Course Objective:

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

Course Learning Outcome:

The knowledge of this course will enable the student to know about various molecular tools and approaches for genotyping and marker assisted breeding, intellectual property rights, bioinformatics tools and their uses in crop improvement.

Theory: 2 Credits /36 Hours

UNIT I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

UNIT II

Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.

UNIT III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

UNIT IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

Practical: 1 Credit /18 Hours

1. Requirements for plant tissue culture laboratory.
2. Techniques in plant tissue culture
3. Media components and media preparation
4. Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations
5. Inoculation of explants, callus induction and plant regeneration; Standardizing the protocols for regeneration
6. Hardening of regenerated plants; Establishing a greenhouse and hardening procedures
7. Visit to commercial micropropagation unit
8. Transformation using Agrobacterium strains
9. GUS assay in transformed cells/ tissues
10. DNA isolation, DNA purity and quantification tests
11. Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship
12. Construction of genetic linkage maps using computer software
13. NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction
14. Tool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder
15. Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl)
16. Primer designing- Primer 3/ Primer BLAST.

Suggested Readings:

1. Azuaje F and Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics.John Wiley and Sons.
2. Brown TA. 1991. Essential Molecular Biology: a practical Approach. Oxford university press,2002, 2nd edition
3. Chawala HS. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt.Ltd.
4. Chopra VL and Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
5. Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
6. Hackett PB, Fuchs JA and Messing JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
7. Jollès P and Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis. Birkhäuser.

8. Lewin B. 2017. Genes XII. Jones & Bartlett learning, 2017.
9. Robert NT and Dennis JG. 2010. Plant Tissue Culture, Development, and Biotechnology. CRC Press.
10. Sambrook J and Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
11. Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani Publishers, New Delhi.
12. Watson J. 2006. Recombinant DNA. Cold Spring harbor laboratory press.

GPB 516 Breeding for Stress Resistance and Climate Change (2+0+1=3) credits 54 Hrs.

About this Course…

Climate change is a big challenge to sustain higher crop productivity and nutritional quality. Concept of breeding for stress tolerance and development of hybrids/varieties for climate change is of prime importance in plant breeding. Therefore, this course is essential for budding plant breeders.

Course Objective:

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

Course Learning Outcome:

After completion of this course the student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL, etc. for pest resistance and Use of standard MAS procedures.

Theory: 2 Credits /36 Hours

UNIT I

Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses –major pests and diseases of economically important crops.

UNIT II

Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods – Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications. Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

UNIT IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

UNIT V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

Practical: 1 Credits /18 Hours

1. Understanding the climatological parameters and predisposal of biotic and abiotic stress factors-ways of combating them for diseases caused by fungi and bacteria.
2. Symptoms and data recording; use of MAS procedures.
3. Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level
4. Phenotypic screening techniques for nematodes and borers; Ways of combating them.
5. Evaluating the available populations like RIL, NIL, etc. for pest resistance.
6. Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops.
7. Breeding for herbicide resistance.
8. Screening crops for drought and flood resistance; factors to be considered and breeding strategies.
9. Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies.
10. Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

Suggested Readings:

1. Blum A. 1988. Plant Breeding for Stress Environments. CRC Press.

2. Christiansen MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments.Wiley International.
3. Fritz RS and Simms EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology,Evolution and Genetics. The University of Chicago Press.
4. Li PH and Sakai A. 1987. Plant Cold Hardiness. Liss, New York Springer
5. Luginpill P. 1969. Developing Resistant Plants - The Ideal Method of Controlling Insects. USDA, ARS, Washington DC.
6. Maxwell FG and Jennings PR. (Eds.). 1980. Breeding Plants Resistant to Insects. John Wiley &Sons. Wiley-Blackwell.
7. Roberto F. 2018. Plant Breeding for Biotic and Abiotic Stress Tolerance. Springer.
8. Russel GE. 1978. Plant Breeding for Pest and Disease Resistance. Butterworths.
9. Sakai A and Larcher W. 1987. Frost Survival in Plants. Springer-Verlag.
10. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
11. Turener NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress.John Wiley & Sons.
12. Van der Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

GPB 518 Plant Genetic Resources and their Utilization
(1+0+1=2) credits 36 Hrs.

About this Course…

Pre-breeding is a vital step in the link between plant genetic resources conservation and its use; Hence, this course is designed to inculcate theoretical and practical know how to understand and use classical and advanced plant breeding methods for planning and execution of prebreeding programmes so that the PGR is put into effective use for food and agriculture.

Course Objective:

To teach theoretical and practical know how on CWRs reproductive behavior, acclimatization and adaptation for utilization in pre-breeding programmes using advanced tools.

Course Learning Outcome:

Students would be conversant with handling of unadapted germplasm, screening methods for special traits-biotic and abiotic resistance, nutritional traits, characterization of CWR, breeding, etc.

Theory: 1 Credit /18 Hours

UNIT I

Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

UNIT II

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable

traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

UNIT III

Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre- and postzygotic barriers.

Practical: 1 Credit/18 Hours

1. Characterization of CWRs by visiting the fields.
2. Screening methods for special traits-biotic and abiotic resistance.
3. Screening for nutritional traits.
4. Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables. Assessment of pre and post-zygotic barriers in wide hybridization crosses.
5. Pollen storage studies.
6. Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, etc.

Suggested Readings:

1. Andey Pereira. 2006. *Plant Reverse Genetics*, Methods and Protocols, Humana Press
2. Bisht *et al*. 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources* **2**(3): 143–151.
3. Dale JW and von Schantz M. 2007. *From genes to genomes. Concepts and applications of DNA technology*. John Wiley & Sons Ltd., Chichester, England.
4. Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E.
5. Simon (eds.), Advances in new crops. Timber Press, Portland.
6. Goodman, RM. 2004. *Encyclopedia of plant and crop science*. Marcel Dekker Inc., Switzerland.
7. Kimber, G and Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.

GPB 524 Analytical Techniques & Instrumental Methods in Soil &Plant Analysis (0+0+2=2) credits 36 Hrs.

About this Course…

This course is included in the syllabus to provide students with a comprehensive understanding of the analytical techniques and instrumental methods used in soil and plant analysis. It covers the principles and practical applications of various analytical methods used in the field of soil and plant analysis.

Course Objective:

The aim of this course student are able to know the basic of chemistry related to soil and plant to carry out different chemical-physical analysis for understanding the key mechanism of plant. The course is

designed to familiar with different instruments, techniques which generally used to determine the content in plant.

Course Learning Outcome:

Gain in proficiency in sampling prior to analysis. Understand and capability of performing basic chemical processes in an analytical laboratory. Perform with confidently measurements on basic analytical instruments (photometers, spectrometers, chromatographs, ion-selective electrodes, UV-vis spectrophotometer assay, HPTLC fingerprint).

Practical: 2 Credits /36 Hours

1. Preparation of reagents, standard solutions, buffers and samples (soil, water, plants). Acid-base titration. Oxidation-reduction titration.
2. Determination of available nitrogen, phosphorus and potassium in soil.
3. Demonstration and hand-on practice for the analysis of organic compounds in soils and plants using UV-vis spectrophotometer assay, HPTLC fingerprint, GC-FID analysis and HPLC-DAD analysis
4. Determination of cation exchange capacity from organic sample. Extraction of exchangeable cations (Ca, Mg, Naand K).
5. Determination of minerals and trace elements in soil and plants by Atomic Absorption Spectrophotometer.
6. Determination of CaCO3 equivalent (lime and gypsum). Estimation of available (DTPA extractable) iron, manganese, copper and zinc in soil.

Suggested Readings:

1. Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
2. Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis.ELBS Longman.

GPB 591 Seminar-I (0+0+1=1) credits 18 Hrs.

About this Course….

Students should be able to demonstrate abilities like to formulate a scientific question, Present scientific approach to solve the problem, gain experience in writing a scientific proposal, learn how to present and explain their research findings to the audience effectively.

PGS 501 Library and Information Services (0+0+1=1) credits 18 Hrs.

About this Course…

In today's information age, access to information is crucial for academic and professional success. Libraries play a vital role in providing access to information resources and services to students, researchers, and professionals. The course on Library and Information Services introduces students to the fundamental concepts of libraries and their services. It familiarizes students with various types of information resources and equips them with the skills required to access and use them efficiently. The

course also provides an overview of modern information technology and its applications in libraries, making students aware of the latest trends and developments in the field.

Course Objective:

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

Course Learning Outcome:

After completing the course, students should be able to effectively use library resources and services, as well as digital tools for information retrieval and management. They should be able to conduct literature surveys, cite sources correctly, and prepare bibliographies. Additionally, they should be able to evaluate information sources and critically analyze information for academic and research purposes. The course will also equip students with transferable skills such as information literacy, critical thinking, and effective communication.

Practical: 1 Credit /18 Hours

UNIT I

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

Suggested readings

1. D. Ridley, the literature review-A step-by-step guide for students (2008), SAGE publication, London
2. A.Fink, Conducting research literature reviews (1999), Thousands Oak SAGE publication

PGS 502 Technical Writing and Communication Skills (0+0+1=1) credits 18 Hrs.

About this Course…

The course on Technical Writing and Communication Skills is included in the syllabus to equip students with the necessary skills required for effective scientific communication. Effective scientific communication is essential in academic and research settings, and this course aims to develop the skills necessary for writing research papers, theses, technical reports, and reviews. The course also aims to improve students' communication skills, including grammar, error analysis, and accentual patterns. Additionally, students will learn how to present scientific papers, participate in group discussions, and face interviews.

Course Objective:

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

Course Learning Outcome:

The course aims to teach students various forms of scientific writing, how to write different sections of a thesis, and how to write abstracts and summaries. Students will also learn about commonly used abbreviations, how to add illustrations and captions, and how to write numbers and dates in scientific writing. Additionally, the course will cover grammar, error analysis, and communication skills such as participating in group discussions and presenting scientific papers.

Practical: 1 Credit /18 Hours

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; pagination, numbering of tables and illustrations
6. Writing of numbers and dates in scientific write-ups
7. Editing and proof-reading
8. Writing of a review article
9. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks)
10. Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription
11. Accentual pattern: Weak forms in connected speech
12. Participation in group discussion
13. Facing an interview
14. Presentation of scientific papers.

Suggested Readings:

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

11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 505 Agricultural Research, Research Ethics and Rural Development Programmes (e-course) (1+0+0=1) credits 18Hrs.

About this Course…

Agricultural research is essential for food security, economic growth, and poverty reduction in developing countries, and this course aims to provide an overview of the global agricultural research system, including its history, scope, and opportunities. The course also covers research ethics, which is critical for ensuring the quality and safety of research conducted in the field of agriculture. Furthermore, the course explores the concept of rural development and its policies and programs, which play a significant role in the socio-economic development of rural areas.

Course Objective:

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

Course Learning Outcome:

The course on Agricultural Research, Research Ethics, and Rural Development Programs aims to provide an understanding of the history of agriculture, global and national agricultural research systems, and the role of research in promoting food security, reducing poverty, and protecting the environment. The course also covers research ethics and the welfare of animals used in research, as well as rural development policies, strategies, and programs, including Panchayati Raj Institutions, cooperatives, and non-governmental organizations. The course aims to equip students with the knowledge and skills to critically evaluate rural development policies and programs and identify constraints in their implementation. Upon completion of the course, students are expected to have a comprehensive understanding of agricultural research and rural development and their ethical considerations.

Theory: 1 Credit /18 Hours

UNIT I

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

UNIT II

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

UNIT III

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

Suggested Readings:

1. Bhalla GS & 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.

SCH 301 Human Values and Professional Ethics (2+0+0=2) credits 36 Hrs

About this Course…

This course delves into the integration of human values, ethical principles, and personal development within the context of Indian ethos. It focuses on self-discovery, mindfulness, and understanding one's role in society and the global community. Through practical exercises such as yoga, music, debates, and engagement with the community, students will explore how these values contribute to personal growth, ethical behavior, and global citizenship.

Course Objective:

- Introduce Indian cultural ethos and its ethical foundations.
- Foster self-discovery, mindful self-inquiry, and ethical awareness.
- Enhance conscious communication, listening, and discernment skills.
- Promote understanding of constitutional values, duties, and global citizenship.
- Develop assertiveness and self-confidence through practical models.
- Explore integrated personality dimensions and holistic well-being.
- Engage in practices like yoga, mindfulness, music, and community service.

Course Learning Outcome:

By course completion, students will:

- Grasp Indian ethos' role in ethical behavior and cultural understanding.
- Display effective communication skills and active listening.
- Recognize and address assumptions, biases, and ethical implications.

- Understand constitutional values and responsibilities as citizens.
- Apply the Conscious Full Spectrum Response model for assertive communication.
- Embrace holistic well-being principles for physical, mental, and social dimensions.
- Engage in practical activities promoting personal growth and community involvement.

Theory: 2 Credit /36 Hours

Unit 1: Introduction to Indian Ethos

Meaning of ethos and cultural essence of India, Scriptures as the base of the Indian Knowledge System (IKS), Integrating the two methodologies: interiorization process for self-exploration, and exterior scientific pursuit for the prosperity of world, The Law of Karma and Nishkama Karma (The Law of action and selfless action)

Practical: Five hours of Yoga practice per week, Ethics through Music and Indian Poetry, Community Engagement

Unit 2: Human Values and Ethics

Knowing the Self and the universal values that we stand for. This is self inquiry & self discovery, Background conversations and deep listening, recognizing the assumptions that we make, the biases we have, and the implications for ethical action. Self-identity: distinguishing and embracing oneself (and others) four profiles (inner potential, social, professional, personality),Distinguish ideology, perspectives beliefs from embodying values.

Practical : Self discovery, self inquiry and Mindfulness , Yama & Niyama of Ashtang Yoga

Unit 3: Constitutional Values and Global Citizenship

Values embedded in the Preamble of the Indian Constitution--Integration of Human Rights and duties, Directive principles and responsibilities as citizens of India, Sensibility and responsibilities towards global environment, Loksangraha and Vasudhaiva Kutumbakam.

Practical: Debates and Theatre on diversity and plurality, research on similarities and differences in the ethos of different countries.

Unit 4: Values and Skills for Youth

Designing to make a difference through strategies using the Conscious Full Spectrum Response model, Listening for commitment behind complaints to transform contentious arguments and create a space for listening and change Distinguishing judgement from discernment, Being assertive and confident (assertiveness incorporates self-confidence)

Practical: Development of concentration among students through music, fine arts, mathematics, sports, yoga and mindfulness

Unit 5: Integrated Personality and Well-being

The three gunas (qualities of sattva—purity and harmony, rajas —activity and passion, tamas — darkness and chaos), the four antah-karanas (inner instruments), and panch kosha (five sheaths), Stress

management: meditated personality and agitated personality, Oneness, non-duality, and equanimity, Physical, mental, social, and spiritual well-being

Practical: Talks on importance of the Ayurvedic concept of well being and nutrition, sports activities. Teaching Pedagogy: The teaching will include classroom lectures, experiential and simulation activities and exercises, hands-on learning tasks and discussions. In addition 15 hours will be reserved for neighbourhood or community engagement and practices such as mindfulness, yoga, sports, music, arts and crafts, etc.

Suggested readings:

1. "Indian Ethos and Values" by R.S. Tripathi
2. "Ethics and Human Values in Family and Consumer Sciences" by Bettye P. Smith
3. "Values and Ethics in Organization and Human Systems Development" by William B. Werther Jr. and William J. McConaty
4. "Ethics for the New Millennium" by Dalai Lama
5. "The Power of Now: A Guide to Spiritual Enlightenment" by Eckhart Tolle
6. "Mindfulness in Plain English" by Bhante Henepola Gunaratana
7. "The 7 Habits of Highly Effective People: Powerful Lessons in Personal Change" by Stephen R. Covey
8. "The Yoga Bible" by Christina Brown
9. "The Bhagavad Gita" translated by Eknath Easwaran
10. "The Book of Joy: Lasting Happiness in a Changing World" by Dalai Lama and Desmond Tutu

Recommended Electives (Semester III)

GPB 507 Breeding for Quality and Special Traits (2+0+1=3) credits 54Hrs.

About this Course…

Quality consciousness is growing in the society and only quality products are in demand in the market so has to be the new varieties. This course acquaints breeding for grain quality parameters in field crops. It will also teach about the genetic engineering protocols for quality improvement: Biofortification in crops and Nutritional genomics and Second generation transgenics.

Course Objective:

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological approaches.

Course Learning Outcome:

The knowledge of this course will expose the student to know about various conventional and genetic engineering techniques for the improvement of quality characters in agricultural and horticultural field crops.

Theory: 2 Credits /36 Hours

Unit I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement - A human perspective.

Unit II

Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit III

Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

Unit IV

Breeding for quality improvement in pulses – Chickpea, pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds -groundnut**,** mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

Unit V

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

Practical: 1 Credit /18 Hours

1. Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;
2. Quality analysis in millets;
3. Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison;
4. Quality parameters evaluation in wheat, pulses and oilseeds;
5. Evaluation of quality parameters in cotton, sugarcane and potato;
6. Value addition in crop plants; Post-harvest processing of major field crops;
7. Quality improvement in crops through tissue culture techniques;
8. Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
9. Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

Suggested Reading:

1. Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding – Biotechnological and Conventional approaches*, Narosa Publications Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.
2. FAO 2001. *SpecialityRices of the World - Breeding, Production and Marketing*. Oxford & IBH,1 Nov 2001.
3. Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
4. Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA.

5. Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
6. Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
7. Singh BD. 1997. *Plant Breeding*. Kalyani Publishers, New Delhi.
8. Singh RK, Singh UK and Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

GPB 508 Mutagenesis and Mutation Breeding (2+0+1=3) credits 54 Hrs

About this Course…

The knowledge of this course will enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding. It will also give in depth knowledge about genomics, allele mining, TILLING, etc. and their utilization in crop improvement programmes.

Course Objective:

To impart the knowledge about general principles of mutagenesis for crop improvement and various tests/ methods for detection of mutations.

Course Learning Outcome:

This course will make the student well versed with the process of mutation and its use in crop improvement. This course will also give in depth knowledge of mutations in genomics, allele mining and TILLING.

Theory: 2 Credits /36 Hours

UNIT I

Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

UNIT II

Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects – RBE and LET relationships; Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry -Objects and methods of treatment; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects; Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume.

UNIT III

Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

UNIT IV

Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

UNIT V

Use of mutagens in creating oligogenic and polygenic variations – Case studies; In-vitro mutagenesis – Callus and pollen irradiation; Handling of segregating M2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical: 1 Credit /18 Hours

1. Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens
2. Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber
3. Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes
4. Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens
5. Procedures in combined mutagenic treatments
6. Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature
7. Study of M1 generation – Parameters
8. Study of M2 generation – Parameters
9. Mutation breeding in cereals and pulses-achievements made and an analysis
10. Mutation breeding in oilseeds and cotton- achievements and opportunities
11. Mutation breeding in forage crops and vegetatively propagated crops
12. Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Suggested Reading:

1. Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London.
2. Chadwick KH and Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.

3. Cotton R, Edkin E and Forrest S. 2000. Mutation Detection: A Practical Approach. Oxford Univ. Press.
4. International Atomic Energy Agency. 1970. Manual on Mutation Breeding. International Atomic Energey Agency, Vienna, Italy.
5. Shu QY, Forster BP and Nakagawa N. 2012. Plant Mutation Breeding and Biotechnology.
6. Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).
7. Singh BD. 2003. Genetics. Kalyani Publishers, New Delhi.
8. Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall.
9. www.barc.gov.in

GPB 509 Hybrid Breeding (2+0+1=3) credits 54 Hrs.

About this Course…

This course will expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops

Course Objective:

To provide knowledge of understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Course Learning Outcome:

After completing this course, the student will be able to know about importance of heterosis, the various conventional and biotechnological approaches for the development of hybrids. This will also enable student to know about the use of male sterility in hybrid seed production of important field crops.

Theory: 2 Credits /36 Hours

UNIT I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

UNIT II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of

heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

UNIT III

Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

UNIT IV

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

UNIT V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

Practical: 1 Credit /18 Hours

1. Characterization of male sterile lines using morphological descriptors.
2. Restorer line identification and diversification of male sterile sources
3. Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them
4. Diversification and restoration
5. Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea
6. Understanding the difficulties in breeding apomicts
7. Estimation of heterotic parameters in self, cross and asexually propagated crops
8. Estimation from the various models for heterosis parameters
9. Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it
10. Hybrid breeding at National and International level, opportunities ahead.

Suggested Readings:

1. Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. Science Publisher London.
2. Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
3. Ben HL. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.

4. Chal GS and Gossal SS. 2002. Principles and procedures of Plant Breeding, Biotechnology and Conventional Approaches. Narosa Publishing House. New Delhi
5. De JG. 1988. Population Genetics and Evolution. Springer-Verlag. 30 January 2012
6. Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
7. Mettler LE and Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall. 25 April 1988
8. Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons. 2013
9. Mukherjee BK. 1995.The Heterosis Phenomenon. Kalyani Publishers, New Delhi.
10. Proceedings of Genetics and Exploitation of Heterosis in Crops – An International Symposium CIMMYT, 1998.
11. Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin. 30 May 1997
12. Singh BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi.
13. Srivastava S and Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II. Anmol Publ.
14. Virmani SS. 1994. Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics", Springer-Verlag.

GPB 510 Seed Production and Certification (2+0+1=3) credits 54 Hrs.

About this Course…

Seed is the essence of life. Its improvement, production and maintenance is an essential feature of any variety. Seed chain concept is highly relevant in commercial promotion of new varieties whereas process of certification is mandatory for quality assurance of seed.

Course Objective:

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures in different crops.

Course Learning Outcome:

After completing this course the student will be able to know about seed production of different crop varieties and hybrids, their processing, marketing and seed laws.

Theory: 2 Credit /36 Hours

UNIT I

Importance of seed as basic input in agriculture; Seed quality concept and importance;Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

UNIT II

Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production and certification.

UNIT III

Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.

UNIT IV

Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

UNIT V

Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

UNIT VI

Seed certification - history, concept, objectives; Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops -General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

Practical: 1 Credit /18 Hours

1. Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony.
2. Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination.
3. Pollen collection and storage methods, pollen viability and stigma receptivity.
4. Pre-harvest sanitation, maturity symptoms, harvesting techniques.
5. Visits to seed production plots - visit to seed industries.
6. Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate.
7. General procedure of seed certification, identification of weed and other crop seeds.as per specific crops, field inspection at different stages of a crop and observations. recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement
8. Specifications for tags and labels to be used for certification purpose.

Suggested Readings:

1. Agrawal PK and Dadlani M. 1987. Techniques in Seed Science and Technology, South Asian
   Publishers, Delhi.
2. Agrawal RL. 1997. Seed Technology, Oxford & IBH Publishing.
3. Anon, 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.
4. Anon. 1999. Manual of Seed Certification procedures. Directorate of Seed Certification,Coimbatore, Tamil Nadu.
5. Joshi AK and Singh BD. 2004. Seed Science and Technology, Kalyani Publishers, New Delhi.
6. Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley, New York.
7. Mc Donald MB and Copeland LO. 1997. Seed Science and Technology, Scientific Publisher, Jodhpur.
8. Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. Seed Legislation in India. Agrobios (India), Jodhpur, Rajasthan.
9. Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi
10. Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

e-Resources

i. www.gov.mb.ca
ii. www.agricoop.nic.in
iii. www.agri.nic.in
iv. www.fao.org
v. www.seednet.gov.in

GPB 520 Breeding Horticultural Crops (2+0+1=3) credits 54Hrs.

About this Course…

This course enables the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

Course Objective:

To educate about principles and practices adopted for breeding of vegetable crops

Course Learning Outcome:

After completion of this course the students will be able to know about the different breeding methods and genetics of major vegetable crops

Theory: 2 Credits /36 Hours

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.
Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper
Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

Unit III

Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit IV

Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, Chrysanthemum, Tuberose, Gerbera, Gladiolus, Dahlia, Lilium, Gaillardia, Petunia, Bouganvillea, Pansy, Marigold, Geranium, Antirrhinum, China aster, Orchids, Carnation, Hibiscus, etc.

Unit V

Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol.

Practical: 1 Credits /18 Hours

1. Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
2. Hybridization and handling segregating generations;
3. Induction of flowering, palanological studies, selfing and crossing techniques.
4. Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in majorfruit crops;
5. Hybrid seed production of vegetable crops in bulk;
6. Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
7. Molecular marker techniques to identify useful traits and special breeding techniques in fruits, vegetable and ornamental crops
8. Polyploidy and mutations to evolve new varieties in ornamental crops
9. Visit to research institutes involved in fruit, vegetables and ornamental crop breeding.

Suggested Reading:

1. Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.
2. Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani Publishers, New Delhi.
3. Kalloo G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.
4. Kalloo G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
5. Peter KV and Pradeep KT. 2008. *Genetics and Breeding of Vegetables.* ICAR.
6. Rai N and Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publication Agency. Ram HH. 2005. *Vegetable Breeding-Principles and Practices*. Kalyani Publishers
7. Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publishers, New Delhi. Singh BD. 1983. *Plant Breeding*. Kalyani Publishers

Total Credits: 21 **Fourth Semester** **Total Hrs.378**

GPB 592 **Seminar-II (0+0+1=1) credits** **18 Hrs.**

Course Objective:

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Course Learning Outcome:

Students should be able to to formulate the scientific question; Present scientific approach to solve the problem; Interpret, discuss and communicate scientific results Learn how to present and explain their research findings to the audience effectively.

GPB 599 **Project work (0+0+20=20) credits** **360 Hrs.**