

**NEW AND RESTRUCTURED
POST-GRADUATE CURRICULA & SYLLABI**

Plant Sciences

Genetics & Plant Breeding
Seed Science & Technology



**Education Division
Indian Council of Agricultural Research
New Delhi**

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EXECUTIVE SUMMARY

Based on the suggestions and feed backs from the members of the BSMA Committee (Plant Sciences) and the stakeholders including the private sectors involving in modern crop improvement and seed production and students, retired experts in the concerned fields, the revised syllabi and curricula on plant sciences which include the courses i) Genetics & Plant Breeding, ii) Seed Science & Technology have been developed for adoption in the SAUs in India.

The revised syllabi and curricula will enable the students at PG level to learn more advanced technologies in the field of Genetics, Plant Breeding and Seed production with hands-on training at the place of their employment after completion of the course.

Provisions are made in the curricula for the students undergoing Masters programme in Seed Science and Technology to undergo attachment training in seed production/processing/marketing and quality evaluation in private/public seed industry for a period of 2-3 months.

A student in the discipline of Genetics and Plant Breeding should take preferably minor courses in the discipline of Biotechnology/Biochemistry/ Agricultural Statistics/Plant Protection subjects.

The above exercises are mainly focussed on updating the course content in accordance with the recent developments in Plant Sciences. The students will get exposed in such a way that they could compete in international forums.

Most SAUs offer combined course in Genetics and Plant Breeding except a few. Hence, all the members of the BSMA on Plant Sciences and stakeholders decided unanimously that a combined course curriculum should be developed for the disciplines of Genetics and Plant Breeding.

Some of the improvements in the syllabi and curricula made on two subjects which come under Plant Sciences are given below.

1. Genetics and Plant Breeding

- New courses including topics in biotechnology, molecular breeding, molecular genetics, maintenance breeding and plant genetic resources were included in the new syllabus.
- Provisions are made to train the students in modern breeding and seed production methods through in-service training.
- Tie-up with private sector seed companies for doing research by the Masters & Doctoral students.

- Practical classes were included in the curriculum for visiting the private sector companies involved in breeding & seed production and genomic research
- A course on “Principles of seed production” is also offered to the Genetics & Plant Breeding students as an optional course.

2. Seed Science and Technology

- New courses and topics including DUS testing and PVP, Maintenance Breeding, Seed Advancement Technologies, Marker Based Seed Purity evaluation & Cultivar identification, and Evaluation and Conservation of Plant Genetic Resources have been included in the new syllabus.
- Provisions are made to train students in modern seed production, processing, marketing and quality control methods through students’ attachment with the public/ private sector organizations.
- Tie-up with private sector seed companies for doing research by the Masters & Doctoral students.
- Practical classes are included in the curriculum for visiting the private and public sector seed companies, certification agencies, quarantine facility and NBPGR.
- Strengthening the infrastructure facilities and training of teacher staffs in the SAUs.

BSMA Committee on Plant Sciences

(Genetics, Plant Breeding, Seed Science & Technology, Plant Genetic Resources)

(Constituted by ICAR vide Office order No. F. No. 13 (1)/2007- EQR dated January 14, 2008)

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PREAMBLE

The internationally well acclaimed Green Revolution success in India came about primarily due to the preparedness of the country in terms of having sufficiently trained human resources in plant breeding, genetics and seed science. This was one exceptional point that India enjoyed in the 1960s compared to other countries where the first seeds of the Mexican wheat varieties also reached at the same time as India. This unique advantage happened because the policy makers had already invested in developing human resource in specific subjects of agricultural sciences, the science of Genetics and Plant Breeding which encompassed at that point of time the concepts of Seed Science and Technology. Soon, realizing the importance of seed as the single basic input that made the maximum dent in upscaling production, the science that needs to be put into practice for improving the quality of seed, its conservation, its maintenance and spread was separately branched off into another linked, yet an independent full-fledged course in the early 1980s. This has now been seen as another important policy that enabled a strategic and scientific deployment of the produce of the science of genetics and plant breeding.

India's spectacular progress in agriculture during past five decades through high yielding varieties of major field crops coupled with intensive use of their improved production technology came about due to its strength in scientific and technical manpower that saw the investment and policies implemented. However, due to changing situations in agriculture as a trade and its vulnerability to changing climate, the pace of progress in agriculture slowed down during past five years and food grains were imported in some years to maintain food stocks. This has attracted the attention of policy planners and researchers alike.

There is an increasing demand for new cultivars possessing potential for higher yield in a dependable manner under high input as well as stressed conditions. With the liberalization of global agricultural trade and the WTO regulations which facilitate the trade of agricultural commodities; the demand for improvement in the qualitative traits of agricultural produce/seed has contributed to the importance of crop improvement and seed production technology.

Yield manifests through integrated physiological and genetic components governing net accumulated biomass and its partitioning. Understanding the genetic control of morphological and anatomical, compositional, process rate as well as process control

traits; photosynthesis, nutrient and water acquisition, tolerance to abiotic and biotic stresses in optimal and suboptimal environments, would be imperative. Also statistical quantification of the genotype x environment interaction and the difference in genetic direction of each genotype vis-à-vis gene activity in different environments is required. Given that genetic variability exists among crop species and their wild relatives, it would be possible to incorporate these characteristic into desirable crop ideotypes for specific production environments and quality of produce using conventional recombination breeding and modern cell and molecular biology and biotechnology based approaches such as marker assisted selection and transgenics.

Emerging scenario of agriculture research and market trends, need for trained manpower for teaching and application of biotechnology and nanotechnology in crop improvement and seed science and technology, shrinking job opportunities in public sector institutes etc, would warrant students to possess strong knowledge base coupled with good practical and management skills, to be competitive for public and private sector. Hence, a thorough restructuring of course curricula and delivery system is needed.

In this proposed revision of the curriculum in the subjects of Genetics & Plant Breeding and Seed Science & Technology, the BSMA sub-group organized a series of meetings and electronic media-led consultations to develop a set of courses that would cater to both M. Sc. and Ph. D. level graduates in the country. The meetings focused on keeping the basic principles of the science genetics, plant breeding and seed technology as the platform building status of basic agricultural or non-agricultural graduates. Built on this platform were the latest state of the art technologies including biotechnology and molecular biology to be put into different modules for enabling a complete coverage of the subjects without compromising on the quality and content in terms of imparting the requisite up to date knowledge as on today. The basic platform courses have therefore been kept as core courses which need to be taken by all the students irrespective of the subject specialization or stream from which they entered into PG education. The latest advancements have been incorporated into these core courses also at foundation levels in units meant to introduce the concepts of the latest developments that have occurred in the science. The open-ness to other streams of graduation has been enabled through the deficiency courses ear-marked to provide a basic ground development among those graduates who had no specific exposure to the science of Genetics & Plant Breeding or Seed Science & Technology. The course curriculum also targets the M. Sc. and Ph. D. graduates separately by providing two sets of courses which are specific to M. Sc. as well

as Ph. D. and some specific to the Ph. D. graduating students only. Again, when making these courses, sufficient inputs have been deliberated by the experts to introduce the concepts of the advanced courses ear-marked for Ph. D. level even in the courses meant for M. Sc. level so that the concept is ingrained when the M. Sc. graduate takes to Ph. D. system.

In addition, few courses both at M. Sc. and Ph. D. levels have been cross-listed across the two disciplines so that the mutual advantages can be shared by graduates developing their expertise in each subject since these cross-listed courses strengthen the graduates in adapting to exploring the knowledge gained through these in their own subject specialization.

An additional input received during the development of the courses was on enabling the Universities in having the basic infrastructure that helps students for having a comprehensive knowledge accumulation with training. The purpose in recommending the infrastructural provision is to develop hands-on expertise among the graduates that builds a confidence in them to be entrepreneurs in their subject, develop R & D avenues in advanced centers both in and outside the country so that the gains get transferred in the form of technologies to the ultimate enduser, the farmer.

The BSMA Committee on Plant Sciences had thread bare discussions over two sessions on the topical issues concerning Genetics and Plant Breeding and Seed Science and Technology. Also some deliberations on and Plant genetic Resources were held. The curricula and syllabi of all these disciplines were discussed at length in the meetings and workshop convened by the BSMA Committee. The opinions and suggestions invited from institutions, eminent scientists, and other stakeholders were reviewed by the BSMA Committee. The new look and restructured PG programmes in Plant Sciences have been designed in considerations based on demands of private sector harnessing commercial aspects, modern research tools and their applications, supplementary skills required, and to enhance the global competitiveness and employability of our students. Considerable efforts have, therefore, gone in for the preparation of this final document.

ORGANIZATION OF COURSE CONTENTS & CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	55	75
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.

GENETICS AND PLANT BREEDING
(Integrated)
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
GP501*	PRINCIPLES OF GENETICS	2+1
GP502*	PRINCIPLES OF CYTOGENETICS	2+1
GP503*	PRINCIPLES OF PLANT BREEDING	2+1
GP504*	PRINCIPLES OF QUANTITATIVE GENETICS	2+1
GP505	MUTAGENESIS AND MUTATION BREEDING	2+1
GP506	POPULATION GENETICS	1+1
GP507	HETEROSIS BREEDING	1+1
GP508*	CELL BIOLOGY AND MOLECULAR GENETICS	2+1
GP509*	BIOTECHNOLOGY FOR CROP IMPROVEMENT	2+1
GP510	BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE	2+1
GP511	BREEDING CEREALS, FORAGES AND SUGARCANE	2+1
GP512	BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS	2+1
GP513	BREEDING FOR QUALITY TRAITS	1+1
GP514	GENE REGULATION AND EXPRESSION	2+0
GP515	MAINTENANCE BREEDING, CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION	1+1
GP 516@	GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE	2 +1
GP 517	DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR	2+1
GP591	MASTER'S SEMINAR	1+0
GP599	MASTER'S RESEARCH	20
GP601	PLANT GENETIC RESOURCES AND THEIR UTILIZATION	2+0
GP602	ADVANCES IN QUANTITATIVE GENETICS	2+1
GP603**	GENOMICS IN CROP IMPROVEMENT	2+1
GP604**	CELLULAR AND CHROMOSOMAL MANIPULATIONS IN CROP IMPROVEMENT	2+1
GP605**	ADVANCED PLANT BREEDING SYSTEMS	2+0
GP606	CROP-EVOLUTION	2+1
GP607	BREEDING DESIGNER CROPS	1+1
GP608	ADVANCES IN BREEDING OF MAJOR FIELD CROPS	3+0
GP609	MICROBIAL GENETICS	2+1
GP610@@	IN SITU AND EX SITU CONSERVATION OF GERMPLASM	2 +1
GP 691	DOCTORAL SEMINAR I	1+0
GP 692	DOCTORAL SEMINAR II	1+0
GP 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Ph. D. programme

@Cross listed with SST 515; @@ Cross listed with SST 602

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings

- Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.
- Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.
- Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.
- Russell PJ. 1998. *Genetics*. The Benjamin/Cummings Publ. Co.
- Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons.
- Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India
- Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Pubs.
- Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

GP 502

PRINCIPLES OF CYTOGENETICS

2+1

Objective

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

Theory

UNIT I

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.

UNIT II

Chromosomal theory of inheritance – Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure: Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications.

UNIT III

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 lethals and chromosome complexes.

UNIT IV

Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids 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 V

Reversion of autopolyploids to diploids; Genome mapping in polyploids - Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids - Bridge species.

UNIT VI

Fertilization barriers in crop plants at pre-and postfertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization ; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation - Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion and *Aloe vera* - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro*; Microtomy and steps in microtomy; Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids; Anther culture and Ovule culture - Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly - Morphological observations on allopolyploids - Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation ; Polyploidy in ornamental crops. -Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH.

Suggested Readings

Becker K & Hardin. 2004. *The World of Cell*. 5th Ed. Pearson Edu.
Carroll M. 1989. *Organelles*. The Guilford Press.
Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall.

- Darlington CD & La Cour LF. 1969. *The Handling of Chromosomes*. Georger Allen & Unwin Ltd.
- Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRL Press.
- Gray P. 1954. *The Mirotomist's Formulatory Guide*. The Blakiston Co.
- Gupta PK & Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A. Elsevier.
- Gupta PK. 2000. *Cytogenetics*. Rastogi Publ.
- Johannson DA. 1975. *Plant Microtechnique*. McGraw Hill.
- Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons.
- Khush GS. 1973. *Cytogenetics of Aneuploids*. Academic Press.
- Sharma AK & Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth.
- Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ.
- Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

GP 503

PRINCIPLES OF PLANT BREEDING

2+1

Objective

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

Theory

UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.

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; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III

Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

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 inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT V

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

UNIT VI

Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII

Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

UNIT VIII

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

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Suggested Readings

- Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.
Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.
Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.
Singh BD. 2006. *Plant Breeding*. Kalyani.
Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani.
Singh P. 2006. *Essentials of Plant Breeding*. Kalyani.
Singh S & Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

GP 504

PRINCIPLES OF QUANTITATIVE GENETICS

2+1

Objective

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

Theory

UNIT I

Mendelian traits vs polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and

environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

UNIT II

Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV

Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D^2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions.

Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted

multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

- Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.
- Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.
- Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.
- Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.
- Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
- Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
- Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GP 505

MUTAGENESIS AND MUTATION BREEDING

1+1

Objective

To impart the knowledge about general principles of radiation and various tests/methods for detection of radiation effects on the living cells, genetic risks involved and perspectives of advances made.

Theory

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 in lower and higher organisms – paramutations.

UNIT II

Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations viz., X rays, γ rays, α and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (α , photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships.

UNIT III

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 IV

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 V

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.

UNIT VI

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 same species – Case studies.

UNIT VII

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

UNIT VIII

Use of mutagens in genomics, allele mining, TILLING.

Practical

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

Suggested Readings

Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.

- Chadwick KH & Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer-Verlag.
- Cotton RGH, Edkin E & Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energy Agency, Vienna, Italy.
- Singh BD. 2003. *Genetics*. Kalyani.
- Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

GP 506

POPULATION GENETICS

2+1

Objective

To impart knowledge on structure, properties and their breeding values of different population.

Theory

UNIT I

Population - Properties of population - Mendelian population – Genetic constitution of a population through time, space, age structure etc. Mating systems - Random mating population - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation.

UNIT II

Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof - Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium - Mating frequencies - Non-dominance - Codominance - Snyder's ratio, importance and its effect over random mating in succeeding generations.

UNIT III

Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency - Migration – Mutation - Recurrent and non-recurrent - Selection - Balance between selection and mutation - Selection favouring heterozygotes - Overdominance for fitness.

UNIT IV

Non random mating: selfing –inbreeding coefficient - panmictic index – sibmating - Assortative mating and disassortative mating - Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops.

UNIT V

Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homeostasis- Adaptive organization of gene pools, Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival of recessive and deleterious alleles in populations.

Practical

Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium- Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental

data; Measurement of genotype-environment interaction; Genetic divergence.

Suggested Readings

- Chawla V & Yadava RK. 2006. *Principles of Population Genetics - A Practical Manual*. Dept. of Genetics, CCS HAU Hisar.
- Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.
- Jain JP, Jain J & Parbhakaran, VT. 1992. *Genetics of Populations*. South Asia Books.
- Li CC. 1955. *Population Genetics*. The Univ. of Chicago Press.
- Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
- Sorrens D & Doniel G. 2007. *Methods in Quantitative Genetics*. Series: *Statistics for Biology and Health*. Likelihood.
- Tomar SS. 1992. *Text Book of Population Genetics*. Universal Publication.

GP 507

HETEROSIS BREEDING

2+1

Objective

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

Theory

UNIT I

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self- and cross-pollinated and asexually propagated crops.

UNIT II

Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis.

UNIT III

Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and 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 inbreds, their improvement for increasing heterosis.

UNIT IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.

UNIT V

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated

crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI

Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

UNIT VII

Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Selection indices and selection differential – Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters -Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

Proceedings of *Genetics and Exploitation of Heterosis in Crops* - An International Symposium CIMMYT, 1998.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.

Ben Hui Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.

De Jong G. 1988. *Population Genetics and Evolution*. Springer-Verlag.

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.

Mettler LE & Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall.

Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons.

Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.

Srivastava S & Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.

GP 508 CELL BIOLOGY AND MOLECULAR GENETICS 2+1

Objective

To impart knowledge in theory and practice about cell structure, organelles and their functions, molecules like proteins and nucleic acids.

Theory

UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids-chloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT IV

Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Practical

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in a bacterial culture.

Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

Suggested Readings

Bruce A.2004. *Essential Cell Biology*. Garland.

Karp G.2004. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley.

Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman & Co.

Lewin B. 2008. *IX Genes*. John Wiley & Sons

Lodish H, Berk A & Zipursky SL. 2004. *Molecular Cell Biology*. 5th Ed. WH Freeman.

Nelson DL & Cox MM. 2005. *Lehninger's Principles of Biochemistry*. WH Freeman & Co.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley Publ. Co.

GP 509

BIOTECHNOLOGY FOR CROP IMPROVEMENT 2+1

Objective

To impart knowledge and practical skills to use biotechnological tools in crop improvement.

Theory

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.), mapping populations (F_2 s, back crosses, RILs, NILs and DH).

UNIT IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

UNIT V

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

UNIT VI

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. Commercial releases.

UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

UNIT VIII

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

UNIT IX

Bioinformatics & Bioinformatics tools.

UNIT X

Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for

regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit.

Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Suggested Readings

Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.

Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

Hackett PB, Fuchs JA & Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

Sambrook J & Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.

Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani.

GP 510

BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE 2+1

Objective

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

Theory

UNIT I

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 - Concepts in 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-defense mechanisms against viruses and bacteria.

UNIT II

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.

UNIT III

Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data - Gene pyramiding methods and their implications.

UNIT IV

Classification of abiotic stresses - Stress inducing factors –moisture stress/drought and water logging & 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 V

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & 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 VI

Exploitation of 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- Achievements.

Practical

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

Suggested Readings

- Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.
- Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.
- Fritz RS & Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.
- Li PH & Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York
- Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.
- Maxwell FG & Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons.
- Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, New York.
- Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.
- Sakai A & Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.
- Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.
- van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

Objective

To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

TheoryUNIT I

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.* – Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

UNIT II

Wheat: 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, exploitation of heterosis *etc.*; Sorghum: 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.*; Pearl millet: 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 III

Maize: 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.* - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.*

UNIT IV

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 grasses: 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.*, synthetics, composites and apomixes.

UNIT V

Forage legumes: 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.* - Tree fodders: 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.*, palatability studies.

UNIT VI

Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

Practical

Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval. Practical learning on the cultivation of fodder crop species on sewage water; analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories, 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

- Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
- Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.
- Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.
- Chopra VL & Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.
- Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.
- IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.
- IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- Jennings PR, Coffman WR & Kauffman HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.
- Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.
- Murty DS, Tabo R & Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.
- Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani.
- Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
- Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.
- Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.

Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

GP 512 BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS 2+1

Objective

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

Theory

UNIT I

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

UNIT II

Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors.

UNIT III

Other pulses: Greengram, blackgram, fieldpea, lentil,, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT IV

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*.

UNIT V

Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc*; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VI

Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc*. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VII

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

UNIT VIII

Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid breeding in castor – opportunities, constraints and achievements.

UNIT IX

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress *etc*.

UNIT X

Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

Practical

Use of descriptors for cataloguing – Floral biology - emasculation – pollination techniques; Study of range of variation for yield and yield components - Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Use of descriptors for cataloguing – Floral biology, emasculation, pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: Use of descriptors for cataloguing – Floral biology - Learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - Study of segregating populations - evaluation - Trait based screening for stress resistance - Cotton fibre quality evaluation – conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation –Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance – Learning the mechanisms of resistance, quantifying the resistance using various parameters; Evaluating the germplasm of cotton for yield, quality and resistance parameters – learning the procedures on development of Bt cotton - Visit to Cotton Technology Laboratory and Spinning Mills – Learning on cotton yarn production, its quality evaluation and uses.

Suggested Readings

- Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
- Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.
- Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.
- Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.

- Nath V & Lal C. 1995. *Oilseeds in India*. Westvill Publ. House.
- Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
- Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
- Singh DP. 1991. *Genetics and Breeding of Pulse Crops*. Kalyani.
- Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. *Crop Breeding in India*. International Book Distributing Co.
- Smartt J. 1994. *The Groundnut Crop - a Scientific Basis for Improvement*. Chapman & Hall.

GP 513

BREEDING FOR QUALITY TRAITS

2+1

Objective

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

Theory

UNIT I

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

UNIT II

Breeding for baking qualities in wheat; Characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

UNIT III

Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in forage crops - Genetic resource management for sustaining nutritive quality in crops.

UNIT IV

Breeding for quality in pulses - Breeding for quality in groundnut, 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.

UNIT V

Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance - Nutritional genomics and Second generation transgenics.

Practical

Grain quality evaluation in rice; Correlating ageing and quality improvement in rice - Quality analysis in millets; Estimation of antinutritional factors like tannins in different varieties/hybrids; A comparison - Quality parameters evaluation in wheat; Quality parameters evaluation in pulses - Quality parameters evaluation in oilseeds; Value addition in crop plants ; Post harvest processing of major field crops; Quality improvement in crops through tissue culture techniques; Evaluating

the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

Suggested Readings

- Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.
- Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.
- FAO 2001. *Speciality Rices of the World - Breeding, Production and Marketing*. Oxford & IBH.
- Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
- Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
- Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
- Singh BD. 1997. *Plant Breeding*. Kalyani.
- Singh RK, Singh UK & Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

GP 514

GENE REGULATION AND EXPRESSION

2+0

Objective

To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

Theory

UNIT I

Introduction: Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

UNIT II

Coordinated genetic regulation-examples- Anthocyanin and gene families and maize; Genetic and molecular basis depending on tissue specificity.

UNIT III

Gene expression-Transposons in plant gene expression, cloning-transposon tagging; Light regulated gene expression-model systems in *Arabidopsis* and maize; Paramutations and imprinting of genes and genomes.

UNIT IV

Transgene expression and gene silencing mechanisms; Regulatory genes-horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

UNIT V

Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

Suggested Readings

- Lewin B. 2008. *Genes IX*. John Wiley & Sons.
- Schleif R. 1986. *Genetics and Molecular Biology*. Addison-Wesley.
- Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
- Brown TA. 2002. *Genomes*. Bios Scientific Publ.
- Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.
- Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.
- Hexter W & Yost HT. 1976. *The Science of Genetics*. Prentice Hall.
- Singer M & Berg P. 1991. *Genes and Genomes*. John Wiley & Sons.

- McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- Musil AF. 1967. *Identification of Crop and Weed Seeds*. Handbook No. 219, USDA, Washington, DC.
- Poehlman JM & Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.
- Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.
- Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.
- Tunwar NS & Singh SV. 1985. *Handbook of Cultivars*. ICAR.

GP 516

**GERMPLASM COLLECTION, EXCHANGE
AND QUARANTINE**

2+1

Objective

To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants.

Theory

UNIT I

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Pre-requisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens; Sampling techniques of plant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques (controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

Suggested Readings

- Briggs D. 1997. *Plant Variation and Evolution*. Science Publ.
- Cronquist AJ. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia Univ. Press.
- Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. *Germplasm Conservation A Compendium of Achievements*. NBPGR, New Delhi.
- di Castri F & Younes T. 1996. *Biodiversity Science and Development: Towards New Partnership*. CABI & International Union for Biol. Sci. France.
- Gurcharan Singh. 2004. *Plant Systematics: An Integrated Approach*. Science Publ.
- Lawrence GMH. (Ed.). 1951. *Taxonomy of Vascular Plants*. London.
- Paroda RS & Arora RK. 1991. *Plant Genetic Resources Conservation and Management Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.
- Pearson LC. 1995. *The Diversity and Evolution of Plants*. CRC Press.
- Singh BP. 1993. *Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management*. Indo-US PGR Project Management.
- Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy*. Science Publ.
- Stace CA. *Plant Taxonomy and Biosystematics* 2nd Ed. Cambridge Univ. Press.
- Takhrayan A. 1997. *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.

Wiersema JH. 1999. *World Economic Plants: A Standard Reference*.
Blanca Leon.

**GP 517 DATA BASE MANAGEMENT, EVALUATION AND 2+1
UTILIZATION OF PGR**

Objective

To train the students in germplasm data base management using modern tools and softwares.

Theory

UNIT I

Statistical techniques in management of germplasm; Core identification, estimation of sample size during plant explorations, impact of sampling on population structure, sequential sampling for viability estimation; Introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and numograms; Estimation of sample size for storage and viability testing.

UNIT II

Germplasm documentation; Basics of computer and operating systems; Database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.

UNIT III

Germplasm management system- global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management.

UNIT IV

Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic resources; Pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; Harmonizing agrobiodiversity and agricultural development crop diversification-participatory plant breeding.

Practical

Basics of computer and operating systems; Identification of useful germplasm, evaluation of crop germplasm; Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing; Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of Characterization of germplasm; Molecular markers and their use in characterization.

Suggested Readings

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.

Puzone L & Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.

Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

GP 601 PLANT GENETIC RESOURCES AND PRE-BREEDING 2+0

Objective

To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.

Theory

UNIT I

Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes.

UNIT II

Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation.

UNIT III

Germplasm conservation- *in situ*, *ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources.

UNIT IV

PGR data base management; Multivariate and clustering analysis, descriptors; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets.

UNIT V

Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality.

UNIT VI

Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of transferred genes and their expression.

UNIT VII

Post-genomic tools for genetic enhancement of germplasm; Prebreeding through chromosome manipulation; Application of biotechnology for Genetic enhancement-Achievements.

UNIT VIII

Utilization of genetic resources, concept of core and mini-core collections, genetic enhancement/Prebreeding for crop improvement including hybrid development.

Suggested Readings

- Frankel OH & Bennett E. 1970. *Genetic Resources in Plants – their Exploration and Conservation*. Blackwell.
- Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. *Plant Germplasm Collecting: Principles and Procedures*. NBPGR, New Delhi.
- Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.
- Paroda RS & Arora RK. 1991. *Plant Genetic Resources, Conservation and Management. Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.
- Puzone L & Hazekamp TH. 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.
- Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.
- Singh RJ & Jauhar PP. 2005. *Genetic Resources, Chromosomal Engineering and Crop Improvement*. Vol. I. *Grain Legumes*, Vol. II. *Cereals*. CRC Press, Taylor & Francis Group, USA.

GP 602

ADVANCED BIOMETRICAL AND QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes.

UNIT II

Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis.

UNIT III

Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

UNIT IV

Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance - Construction of saturated linkage maps, concept of framework map development; QTL mapping- Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of softwares in analysis and result interpretation - Triallel analysis– use of softwares in analysis and result interpretation - Quadriallel analysis – use of softwares in analysis and result interpretation - Triple Test Cross (TTC) – use of softwares in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes. Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Suggested Readings

- Bos I & P Caligari. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.
- Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.
- Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
- Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
- Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GP 603

GENOMICS IN PLANT BREEDING

2+1

Objective

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory

UNIT I

Introduction to the plant genome- Plant nuclear genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.

UNIT II

Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III

Regulation of Plant gene expression - Functional genomics - Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV

Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.

UNIT V

Detection of Single Nucleotide Polymorphism; TILLING and Eco-TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI

Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization - Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers – QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases – Comparative genomics – Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING – DNA Array Technology – Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

- Baxevanis AD & Ouellette BFF. 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience.
- Brown TA. 2002. *Genomes*. Wiley-LISS.
- Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.
- Cantor CR & Smith CL (2004). *Genomics*. Wiley, New York.
- Galas DJ & McCormack SJ. 2002. *Genomic Technologies: Present and Future*. Calster Academic Press.
- Jordan BR. 2001. *DNA Microarrays: Gene Expression Applications*. Springer-Verlag.
- Liu BH. 1997. *Statistical Genomics: Linkage, Mapping and QTL Analysis*. CRS Press.
- Lynch M & Walsh B. 1998. *Genetics and Analysis of Quantitative Traits*. Sinauer Associates.
- Mount DW. 2001. *Bioinformatics. Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press..
- Palzkill T. 2002. *Proteomics*. Kluwer.
- Paterson AH. 1996. *Genome Mapping in Plants*. Academic Press.

- Pennington SR & Dunn MJ. 2002. *Proteomics: From Protein Sequence to Function*. Viva Books.
- Rampal JB. 2001. *DNA Arrays: Methods and Protocols*. Humana Press.

GP 604

**MOLECULAR AND CHROMOSOMAL MANIPULATIONS 2+0
FOR CROP BREEDING**

Objective

This course focuses on the advanced techniques in analyzing chromosome structure and manipulations for genome analysis in crop species.

Theory

UNIT I

Organization and structure of genome – Genome size – Organization of organellar genomes – Nuclear DNA organization – Nuclear and Cytoplasmic genome interactions and signal transduction; Transcriptional and Translational changes, Inheritance and expression of organellar DNA; Variation in DNA content – C value paradox; Sequence complexity – Introns and Exons – Repetitive sequences – Role of repetitive sequence.

UNIT II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/genomic segments; Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT III

Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange-genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

UNIT IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics- methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

UNIT V

Barriers to interspecific and intergeneric hybridization- Behaviour of interspecific and intergeneric crosses; Totipotency of cells – Morphogenesis: *in vivo* and *in vitro* – Meristem culture – anther and pollen culture – ovule, ovary, embryo and endosperm culture – protoplast isolation and culture – protoplast fusion, Different pathways of *in vitro* morphogenesis – organogenesis and somatic embryogenesis; *in vitro* mutant/somaclone selection for biotic and abiotic stresses.

Suggested Readings

- Clark MS & Wall WJ. 1996. *Chromosomes: The Complex Code*. Chapman & Hall.
- Conger BV. (Ed.). 1981. *Cloning Agricultural Plants via in vitro Techniques*. CRC Press.

utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities.

UNIT VI

Genetic engineering technologies to create male sterility; Prospects and problems - Use of self- incompatibility and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male steriles - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genic Male Sterility (EGMS) - Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding - Incongruity - Factors influencing incongruity - Methods to overcome incongruity mechanisms.

Suggested Readings

- Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.
- Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.
- Briggs FN & Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.
- Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.
- Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
- Mandal AK, Ganguli PK & Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.
- Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.
- Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.
- Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani.
- Singh P. 1996. *Essentials of Plant Breeding*. Kalyani.
- Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.
- Williams W. 1964. *Genetical Principles and Plant Breeding*. Blackwell.

GP 606

CROP EVOLUTION

2+0

Objective

To impart knowledge on crop evolutionary aspects and manipulation at ploidy level for crop improvement.

Theory

UNIT I

Origin and evolution of species; Centres of diversity/origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies.

UNIT II

Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT III

Speciation and domestication – The process of speciation – Reproductive isolation barriers – Genetic differentiation during speciation – Hybridization - speciation and extinction.

UNIT IV

Exploitation of natural variation – Early attempts to increase variation – Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

UNIT V

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction – Intergenic interaction – Genome introgression.

UNIT VI

Methods to study crop evolution - Contemporary Methods – Based on morphological features – Cytogenetic analysis – Allozyme variations and crop evolution – DNA markers, genome analysis and comparative genomics.

UNIT VII

Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, use of autopolyploids; haploidy-method of production and use; allopolyploids- synthesis of new crops; - Case studies – Cereals – Pulses – Oilseeds – vegetables, Fibre crops - Plantation crops – Forage crops – Tuber crops – Medicinal Plants.

Suggested Readings

Hancock JF. 2004. *Plant Evolution and the Origin of Crop Species*. 2nd Ed. CABI.

Ladizinsky G. 1999. *Evolution and Domestication*. Springer.

Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.

Smartt J & Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

GP 607

BREEDING DESIGNER CROPS

2+1

Objective

To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification and industrial/pharma applications in plant breeding.

Theory

UNIT I

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

UNIT II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement.

UNIT III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

UNIT IV

Breeding for special traits viz. oil, protein, vitamins, amino acids etc.; Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming

UNIT V

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management

Practical

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

Suggested Readings

- Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.
- Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
- Pessaraki M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.
- Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

GP 608

ADVANCES IN BREEDING OF MAJOR FIELD CROPS

3+0

Objective

To provide insight into recent advances in improvement of cereals, millets and non cereal crops using conventional and modern biotechnological approaches.

Theory

UNIT I

History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum , Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.

UNIT II

Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT III

Breeding for value addition and resistance to abiotic and biotic stresses.

UNIT IV

Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT V

National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings

- Chopra VL. 2001. *Breeding Field Crops - Theory and Practice*. Oxford & IBH.
- Davis DD. 1978. *Hybrid Cotton Specific Problems and Potentials*. Adv. Agron. 30: 129-157.
- Heyne EG. 1987. *Wheat and Wheat Improvement*. 2nd Ed. ASA, CSSA, SSSA Inc Publ.
- Khairwal, IS, Rai KN & Harinarianan H. (Eds.). 1999. *Pearl Millet Breeding*. Oxford & IBH.
- Khairwal I, Ram C & Chhabra AK. 1990. *Pearl Millet Seed Production and Technology*. Manohar Publ.
- Nagarajan S, Singh G & Tyagi BS. 1998. *Wheat Research Needs Beyond 2000 AD*. Narosa.
- Nanda JS. 2000. *Rice Breeding and Genetics - Research Priorities and Challenges*. Oxford & IBH.
- Rao VS, Singh G & Misra SC. 2004. *Wheat: Technologies for Warmer Areas*. Annamaya Publ.
- Reynolds MP, Rajaram S, McNab A. 1996. *Increasing Yield Potential in Wheat: Breaking the Barriers*. Proc. Workshop held in Ciudad, Obregon, Sonora, Mexico.
- Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & Josi AB. 1960. *Cotton in India – A Monograph*. Vol. I. ICAR.
- Singh BD. 2006. *Plant Breeding - Principles and Methods*. Kalyani.
- Singh P & Singh S. 1998. *Heterosis Breeding in Cotton*. Kalyani.
- Singh P. 1998. *Cotton Breeding*. Kalyani.
- Singh S & Singh P. 2006. *Trends in Wheat Breeding*. Kalyani Publ.

GP 609

MICROBIAL GENETICS

2+1

Objective

The objective of this course is to apprise the students of molecular processes at DNA and RNA level in different microorganisms, especially bacteria and viruses.

Theory

UNIT I

Nature of bacterial variation; Molecular aspects of mutation; Episomes and plasmids; Gene mapping in bacteria; Life cycle of bacteriophages; Genetic fine analysis of rII locus; Circular genetic map of phage T4; Transposable elements; Gene manipulation; Biochemical genetics of *Neurospora* and *Sacharomyces* ; One gene - one enzyme hypothesis.

UNIT II

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression; Genetic basis of apoptosis.

UNIT III

Transgenic bacteria and bioethics; genetic basis of nodulation, nitrogen fixation and competition by rhizobia, genetic regulation of nitrogen fixation and quorum sensing in rhizobia; genetics of mitochondria and chloroplasts.

Practical

Preparation and sterilization of liquid and agar bacterial nutrient media; Assessment of generation time in the log-phase bacterial cultures.

Handling of microorganisms for genetic experiments; Isolation of rhizobia from nodules; Gram staining of rhizobial cells; Examination of polyhydroxy butyrate (PHB) production in rhizobia; Demonstration of N₂-fixing nodules/bacterial inoculation in the legume- *Rhizobium* symbiotic system.

Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria; determination of spontaneous and induced mutation frequencies; Discrete bacterial colony counts for the preparation of survival curves and determination of LD₅₀ of a mutagen.

Tn-mediated mutagenesis; Analysis and isolation of plasmid DNA; Curing of plasmids.

Suggested Readings

Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.

Brown TA. 2002. *Genomes*. Bios Scientific Publ.

Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.

Hexter W & Yost HT 1976. *The Science of Genetics*. Prentice Hall.

Karp G. 2004. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley.

Lewin B. 2008. Genes IX. John Wiley & Sons.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Schleif R. 1986. *Genetics and Molecular Biology*. Addison-Wesley Publ. Co.

Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.

Watson JD. 2004. *Molecular Biology of the Gene*. Pearson Edu.

Yadav AS, Vasudeva M, Kharab P & Vashishat RK. 2002. *Practical Manual on Microbial and Molecular Genetics*. Dept. of Genetics, CCS HAU Hisar.

GP 610

***IN SITU AND EX SITU CONSERVATION OF GERMPLASM* 2+1**

Objective

To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ*

conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.

UNIT III

In vitro storage, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems , prospects of *in vitro* gene bank.

UNIT IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants,dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops.Problems and prospects; challenges aheads.

Practical

In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, packaging, documentation; design of cold storage modules- Conservation protocols for recalcitrant and orthodox seeds; Cytological studies for assessing genetic stability, *in vitro* cultures- embryo,cell/suspension cultures,pollen cultures, study of cryotank facility and vitrification techniques, visit to NBPGR/NBAGR -study using fruit crops and other horticultural crops.

Suggested Readings

- Ellis RH & Roberts EH & White Head J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO / IBPGR Pl. Genet. Resources News 41-3-18.
- Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, Cambridge.
- Simmonds, N.W. 1979. *Principles of Crop Improvement* Longman.
- Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository Processed Report*. USDA-ARS and Oregon State Univ. Oregon, USA.
- Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

GENETICS AND PLANT BREEDING

List of Journals

- Australian Journal of Biological Sciences, Australia
- Australian Journal of Agricultural Research, Australia
- Biometrics, UK
- BioTechniques
- Cereal Research Communication, Hungary
- Cotton Research and Development, Hisar, India
- Crop Improvement, Ludhiana
- Crop Science, USA
- Current Science, Bangalore
- Critical Reviews in Plant Sciences
- Czech Journal of Plant Breeding Genetics, Prague,
- Electronic Journal of Biotechnology
- Euphytica, The Netherlands
- FABIS Newsletter
- Forage Research, Hisar, India
- Genetics, USA
- Genome, Canada
- Genetic resources and crop evolution, Netherlands
- Haryana Agricultural University Journal of Research, Hisar, India
- Heredity
- Hilgardia, Sweden,
- Indian Journal of Agricultural Research, New Delhi
- Indian Journal of Genetics and Plant Breeding, New Delhi
- Indian Journal of Plant Genetic Resources, New Delhi
- International Chickpea Newsletter, ICRISAT
- International Rice Research Notes, IRRI, Philippines
- Journal of Agricultural Research, U.K.
- Journal of Biochemistry and Biotechnology, New Delhi
- Journal of Genetics and Breeding, Italy
- Journal of Heredity
- Journal of Pulses Research, Kanpur
- Legume Research, Karnal
- MILWAI Newsletter
- Madras Agricultural Journal, Coimbatore, India
- Molecular Breeding, USA
- Mutation Research
- National Journal of Plant Sciences, Hisar, India
- Nucleic Acids Research, USA
- Oryza, Cuttack, India
- PGR Newsletter, Syria
- Plant Breeding, Germany
- Plant Molecular Biology, The Netherlands
- Rachis, Syria
- Sorghum and Millet Newsletter, ICRISAT
- Theoretical and Applied Genetics, Germany
- Wheat Research, Japan

e-Resources

Name of the Journal	URL
Agronomy Research	http://www.eau.ee/~agronomy/
Asian Journal of Plant Sciences	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ajps
Breeding Science	http://www.jstage.jst.go.jp/browse/jsbbs
Current Science	http://www.ias.ac.in/currsci/index.html
International Journal of Botany	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ijb
International Journal of Sociology of Agriculture and Food	http://www.csafe.org.nz/ijsaf/
Japan Agricultural Research Quarterly	http://ss.jircas.affrc.go.jp/english/publication/jarq/index.html
Japanese Journal of Crop Sc.	http://www.jstage.jst.go.jp/browse/jcs
Journal of Agronomy	http://ansijournals.com/3/c4p.php?id=1&theme=3&jid=ja
Journal of Biosciences	http://www.ias.ac.in/jbiosci/index.html

Journal of Cotton Science	http://www.cotton.org/journal/
Journal of Genetics	http://www.ias.ac.in/jgenet/index.html
Plant Biotechnology	http://www.jstage.jst.go.jp/browse/plantbiotechnology
Plant Production Science	http://www.jstage.jst.go.jp/browse/pps
Scientia Agraria	http://calvados.c3sl.ufpr.br/ojs2/index.php/agraria
Tropicultura	http://www.bib.fsagx.ac.be/tropicultura/
Turkish Journal of Agriculture and Forestry Sciences	http://journals.tubitak.gov.tr/agriculture/index.php

Other Major Portals for Genetics and Plant Breeding

<http://www.icrisat.org/>

<http://121.244.161.11/Search/QuickSearch.asp>

<http://www.plantstress.com/WRFiles/literaturewr.htm> (portal for several sites)

http://www2.unil.ch/lpc/docs/index_plants.htm (portal for several sites)

<http://www.dnaftb.org/dnaftb/> (portal for several sites)

Suggested Broad Areas for Master's and Doctoral Research

- ⊕ Studies on introgressions, gene transfers, gene identification, location and localization with the application of technologies such as, *in situ* hybridization, chromosome identification like FISH (Fluorescent *In Situ* Hybridization), GISH (Genomic *In Situ* Hybridization), Spectral Karyotyping (SKY) and Multiplex Fluorescence *In Situ* Hybridization (M-FISH) etc.
- ⊕ Studies on stay-green traits in relation to genes affecting efficiency of photosynthesis, biotic/abiotic stress tolerance
- ⊕ Genetics of AGP system for better photosynthesis and translocation
- ⊕ Identification of genes/QTLs for NUE and WUE
- ⊕ Molecular markers tagged to genes/QTLs identified for improvement of nutrient use efficiency, water use efficiency
- ⊕ MAS based mobilization of transgenes for tolerance to biotic and abiotic stresses into desirable agronomic backgrounds
- ⊕ Breeding methodologies to enhance selection efficiency
- ⊕ Component approaches and development of selection criteria for quantitative trait improvement
- ⊕ Stability analyses and methods to estimate the G X E components in breeding materials
- ⊕ Relative efficiency analyses of genetic component estimation for reliable use in developing selection criteria in crop plants
- ⊕ Distance and divergence statistics for identification of similarity assessment among genetic stocks and parental genetic material
- ⊕ Linear and quadratic distance measures to identify relative contribution of component traits for complex traits
- ⊕ Studies on genetic and molecular bases of stress tolerance to develop molecular diagnostics for screening/identification of stress tolerant genotypes
- ⊕ Use of aneuploids for gene location and source for transfer through wild species

- ⊕ Development and trisomic and monosomic series in diploids and polyploids
- ⊕ Dependable marker systems for detection of introgression in wide crosses with minimized linkage drag
- ⊕ Analysis of Resistance Gene analogues and their use in MAS with enhanced disease resistance
- ⊕ Analysis of Gene analogues and expression synteny and their use in MAS with enhanced quality and trait expression
- ⊕ Refinements in embryo rescue and consequent diploidization for production of double haploids
- ⊕ Use of molecular markers in phylogenetic analysis
- ⊕ Breeding through distant hybridization route for New Plant Type for breaking yield barriers
- ⊕ Genetics of durable, quantitative resistance and adult plant resistance in major crops against known pathogens
- ⊕ Development of tools and methodologies for identification of genes responsible for resistance against polyphagous insects
- ⊕ Development of alien addition lines and telocentric lines in crops
- ⊕ Microarray technique and robotics for identification of useful genes in crops
- ⊕ Characterization of germplasm through molecular and serological techniques
- ⊕ Induction of novel variation through mutagenesis tools and identify novel genes for different traits
- ⊕ Development of heterotic pools for maximized heterosis in cross and self pollinated crops where hybrid seed production tools are available
- ⊕ Genetics and traits responsible for terminal and initial heat tolerance in wheat, maize and mustard
- ⊕ Genetics of cold tolerance related traits in maize, rice and pigeonpea
- ⊕ Widening the QPM base in maize and prebreeding to add value to the genetic stocks of QPM
- ⊕ Comparison of relative efficiency of different softwares in analysis of quantitative trait loci and linkages
- ⊕ Biochemical and molecular bases of signal transduction in host-pathogen interactions
- ⊕ Metal binding proteins for identification of phytoremediators
- ⊕ Crop improvement for biomass energy and industrial use
- ⊕ Development of cytogenetic stocks through varietal/alien chromosome substitutions

SEED SCIENCE AND TECHNOLOGY

Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
SST 501*	FLORAL BIOLOGY, SEED DEVELOPMENT & MATURATION	1+1
SST 502*	PRINCIPLES OF SEED PRODUCTION	2+0
SST 503*	SEED PRODUCTION IN FIELD CROPS	2+1
SST 504	SEED PRODUCTION IN VEGETABLES	2+1
SST 505	SEED PRODUCTION IN FLOWER, MEDICINAL FRUITS AND PLANTATION CROPS	2+1
SST 506*	SEED LEGISLATION AND CERTIFICATION	2+1
SST 507*	SEED PROCESSING AND STORAGE	2+1
SST 508*	SEED QUALITY TESTING	2+1
SST 509	SEED PHYSIOLOGY	2+1
SST 510	SEED PATHOLOGY	2+1
SST 511	SEED ENTOMOLOGY	2+1
SST 512	SEED PRODUCTION IN PASTURE, FORAGE AND GREEN MANURE CROPS	2+1
SST 513	SEED STORAGE AND DETERIORATION	1+1
SST 514	SEED MARKETING AND MANAGEMENT	1+1
SST 515	EMERGING TRENDS IN SEED QUALITY ENHANCEMENT	1+1
SST 516 [@]	DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR	2+1
SST 591	MASTER'S SEMINAR	1+0
SST 599	MASTER'S RESEARCH	20
SST 601**	HYBRID SEED PRODUCTION	1+1
SST 602 ^{@@}	<i>IN SITU</i> AND <i>EX SITU</i> CONSERVATION OF GERMPLASM	2+1
SST 603	TESTING FOR GENUINENESS & PURITY OF CULTIVARS	1+1
SST 604**	DUS TESTING FOR PLANT VARIETY PROTECTION	2+1
SST 605**	ADVANCES IN SEED SCIENCE RESEARCH	1+0
SST 691	DOCTORAL SEMINAR I	1+0
SST 692	DOCTORAL SEMINAR II	1+0
SST 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Ph. D. programme,
 @ Cross listed with GP 516; @@ Cross listed with GP 609

SEED SCIENCE AND TECHNOLOGY

Course Contents

SST 501 **FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION** **1+1**

Objective

To refresh the basic knowledge of seed development and structures and apprise students with its relevance to production of quality seed.

Theory

UNIT I

Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and megasporogenesis; gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology.

UNIT II

Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.

UNIT III

Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.

UNIT IV

Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practical

Study of floral biology of monocots and dicots; microsporogenesis and megasporogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

Suggested Readings

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

Objective

To introduce the basic principles of quality seed production.

TheoryUNIT I

Introduction : Seed as basic input in agriculture; seed development in cultivated plants; seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops.

UNIT II

Mode of pollination and reproduction in crop plants and their modification in relation to hybrid seed production. Principles of hybrid seed production, isolation distance, synchronization of flowering, roguing etc. male sterility and incompatibility system in hybrid seed production, role of pollinators and their management.

UNIT III

Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved; life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops.

UNIT IV

Hybrid Seed - Methods of development of hybrids; use of male sterility and self-incompatibility and CHA in hybrid seed production; one, two and three line system; maintenance of parental lines of hybrids; planning and management of hybrid seed production technology of major field crops and vegetables.

UNIT V

Planning of seed production for different classes of seeds for self and cross-pollinated crops, Seed quality control system and organization, seed village concept; Seed production agencies, seed industry and custom seed production in India.

Suggested Readings

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

SST 503

SEED PRODUCTION IN FIELD CROPS

2+1

Objective

To impart a comprehensive knowledge of seed production in field crops with adequate practical training.

Theory

UNIT I

Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.

UNIT II

Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc ; methods and techniques of quality seed production in cross-pollinated cereals and millets.

UNIT III

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green gram, black gram, field beans, peas etc.).

UNIT IV

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).

UNIT V

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

Practical

Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in Cotton, detasseling in Corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc.

Suggested Readings

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

SST 504

SEED PRODUCTION IN VEGETABLES

2+1

Objective

To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training

Theory

UNIT I

Introduction; modes of propagation in vegetables. Seed morphology and development in vegetable seeds. Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable

areas/locations for seed production of these crops.

UNIT II

Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.

UNIT III

Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

UNIT IV

Share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; exercises on emasculation and pollination; seed extraction methods and their effect on quality of vegetables; seed production technology of varieties and hybrids in vegetables.

Suggested Readings

- Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.
- Desai BB, Katecha, PM & Salunke DK. 1997. *Seed Hand Book: Biology, Production, Processing and Storage*. Marcel Dekker.
- Desai BB. 2004. *Seeds Handbook*. Marcel Dekker.
- George RAT. 1980. *Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control*. FAO, Rome.
- Hartman HT & Kester DE. 2000. *Plant Propagation: Principles and Practices*. Prentice Hall.
- Kelly AF & George RAT. (Eds.). 1998. *Encyclopedia of Seed Production of World Crops*. John Wiley & Sons.
- McDonald MB Jr & Copeland LO. 1997. *Seed Production of Crops: Principles and Practices*. Chapman & Hall.
- Salunke DK, Desai BB & Bhat RN. 1987. *Vegetable and Flower Seed Production*. Agricole Publ. Academy.
- Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech.
- Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.

Objective

To impart comprehensive knowledge of seed production in horticultural crops with adequate practical training

TheoryUNIT I

Introduction: modes of propagation in fruits, flower and plantation crops. Floral biology of these plant species; classification of medicinal and horticultural crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Flowers and Medicinal Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important flower species i.e. marigolds, petunias, dahlia, roses, gladiolus, tulips, chrysanthemum etc; development of hybrids and their seed production technology flower plants. Seed production technology of annual medicinal plants viz. isabgol, ashawagandha etc.

UNIT III

Fruit and Plantation Crops: role of seed in perennial plant species; classification based on reproduction and pollination behavior; polyembryony and its significance; nursery requirement, planning and management; clonal propagation and multiplication in tropical, sub-tropical and temperate fruits and plantation crops; seed orchards; seed collection, extraction and processing.

UNIT IV

IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of flowers, fruits, medicinal and plantation crops; determination of planting ratios for hybrid seed production in flowers; exercises on emasculation and pollination; seed extraction methods and their effect on quality of fruit; seed production technology of varieties and hybrids; seed collection and extraction in fruit and plantation crops.

Suggested Readings

- Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.
 Desai BB, Katecha, PM & Salunke DK. 1997. *Seed Hand Book: Biology, Production, Processing and Storage*. Marcel Dekker.
 Desai BB. 2004. *Seeds Handbook*. Marcel Dekker.
 Doijode SD. 2001. *Seed Storage of Horticultural Crops*. CBS.
 George RAT. 1980. *Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control*. FAO, Rome.
 Hartman HT & Kester DE. 2000. *Plant Propagation: Principles and Practices*. Prentice Hall.
 ICAR. *Hand Book of Horticulture*. ICAR Publ.

Practical

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 at harvesting/threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.

Suggested Readings

- Agarwal RL. 1997. *Seed Technology*. Oxford & IBH.
Anonymous 1992. *Legislation on Seeds*. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.
Nema NP. 1986. *Principles of Seed Certification and Testing*. Allied Pubs.
Tunwar NS & Singh SN. 1988. *Indian Minimum Seed Certification Standards*. CSCB, Ministry of Agriculture, New Delhi.

SST 507

SEED PROCESSING AND STORAGE

2+1

Objective

To impart knowledge on the principles and techniques of seed processing for quality upgradation and of storage for maintenance of seed quality.

Theory

UNIT I

Introduction: Principles of seed processing; methods of seed drying including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage; loss of viability in important agricultural and horticultural crops, viability equations and application of nomograph.

UNIT II

Seed cleaning equipment and their functions: Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines; seed blending.

UNIT III

Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant.

UNIT IV

Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; Packaging: principles, practices and materials; bagging and labeling.

UNIT V

Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation.

Practical

Operation and handling of mechanical drying equipments; effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds; seed extraction methods; seed processing equipments; seed treating equipments; visit to seed processing plant and commercial controlled and uncontrolled Seed Stores;. seed quality upgradation; measurement of processing efficiency; seed blending, bag closures; study of orthodox, intermediary and recalcitrant seeds; evaluating seed viability at different RH and temperature levels and packaging materials; prediction of storability by accelerated ageing controlled deterioration tests.

Suggested Readings

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

SST 508

SEED QUALITY TESTING

2+1

Objective

To provide a comprehensive knowledge on all aspects of seed quality evaluation and their relevance to crop performance.

Theory

UNIT I

Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA and its role in seed testing.

UNIT II

Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory.

UNIT III

Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable

varieties (ODV); determination of test weight and application of heterogeneity test.

UNIT IV

Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results.

UNIT V

Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy.

UNIT VI

Viability and Vigour Testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.

UNIT VII

Genetic purity testing : objective and criteria for genetic purity testing; types of test; laboratory, Growth Chamber and field testing based on seed , seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests.

UNIT VIII

Seed health Testing: field and seed standards ; designated diseases, objectionable weeds - significance of seed borne disease vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes.

UNIT IX

Testing of GM seeds and trait purity, load of detection (LOD).

UNIT X

Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practical

Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agri-horticultural crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests applicable in various crops; species & cultivar identification; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases, blotter

methods, agar method and embryo count methods; testing coated/pelleted seeds.

Suggested Readings

- Agarwal RL. 1997. *Seed Technology*. Oxford & IBH.
Agrawal PK & Dadlani M. 1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publ.
Agrawal PK. (Ed.). 1993. *Handbook of Seed Testing*. Ministry of Agriculture, GOI, New Delhi.
Copland LO & McDonald MB. 1996. *Principles of Seed Science and Technology*. Kluwer.
ISTA 2006. *Seed Testing Manual*. ISTA, Switzerland.
Martin C & Barkley D. 1961. *Seed Identification Manual*. Oxford & IBH.
Tunwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

SST 509

SEED PHYSIOLOGY

1+1

Objective

To provide an insight into physiological processes governing seed quality and its survival.

Theory

UNIT I

Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.

UNIT II

Seed germination; factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and inter-conversion pathways.

Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.

UNIT III

Seed viability and longevity, pre and post-harvest factors affecting seed viability ; seed ageing ; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.

UNIT IV

Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour in relation to crop performance and yield. Seed invigoration and its physiological and molecular control.

Practical

Proximate analysis of chemical composition of seed; methods of testing viability; kinetics of seed imbibition and solute leakage; seed germination and dormancy breaking methods; seed invigoration and priming treatments; accelerated ageing and controlled deterioration tests; enzymatic activities and respiration during germination and effect of accelerated ageing; vigour testing methods etc.

Suggested Readings

- Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Baskin CC & Baskin JM. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination*. Academic Press.
- Basra AS. 2006. *Handbook of Seed Science and Technology*. Food Product Press.
- Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.
- Bewley JD & Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination*. Vols. I, II. Springer Verlag.
- Bewley JD & Black M. 1985. *Seed: Physiology of Seed Development and Germination*. Plenum Press.
- Copeland LO & Mc Donald MB. 1995. *Principles of Seed Science and Technology*. 3rd Ed. Chapman & Hall.
- Khan AA. 1977. *Physiology and Biochemistry of Seed Dormancy and Germination*. North Holland Co.
- Kigel J & Galili G. (Eds.). *Seed Development and Germination*. Marcel Dekker.
- Murray DR. 1984. *Seed Physiology*. Vols. I, II. Academic Press.
- Sadasivam S & Manickam A. 1996. *Biochemical Methods*. 2nd Ed. New Age.

SST 510

SEED PATHOLOGY

2+1

Objective

To acquaint the students with principles and practices of seed health testing and management of seed borne diseases.

Theory

UNIT I

History and economic importance of seed pathology in seed industry and plant quarantine; terminology, important seed transmitted pathogens; seed microbes and their mode of action, detection techniques and identification of common seed borne pathogens.

UNIT II

Morphology and anatomy of typical monocotyledonous and dicotyledonous seeds; mode and mechanism of transmission of seed borne pathogens and microorganisms. Rate of transmission of major plant pathogens, microorganisms in relation to seed certification and tolerance limit; type of losses caused by seed- borne diseases.

UNIT III

Role of microorganisms in seed quality deterioration; management of seed-borne plant pathogens/diseases and procedure for healthy seed production; different seed health testing methods for detecting microorganisms; treatments to control seed borne diseases.

UNIT IV

Pest Risk Analysis (PRA) and disease free seed production, Sanitary & Phytosaintory (SPS) requirements in seed trade, International regulation (ISHI) in respect of seed health standards.

Practical

Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, detection of seed-borne fungi, bacteria and viruses, identification of storage fungi, control of seed borne diseases, seed treatment methods.

Suggested Readings

Agarwal VK & Sinclair JB. 1997. *Principles of Seed Pathology*. Boca Raton.
Karuna V. 2007. *Seed Health Testing*. Kalyani.
Neergaard P. 1988. *Seed Pathology*. Mac Millan.

ST 511

SEED ENTOMOLOGY

2+1

Objective

To apprise about the role of insects in seed production and their effect on seed quality during storage.

Theory

UNIT I

Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.

UNIT II

Principles of insect pollination, role of pollinators in seed production. Augmenting quality seed production through honeybee pollination in crucifers and forage legumes. Plant protection measures in bee pollinated crops. Management of pollinators for hybrid seed production.

UNIT III

Major insect pests of principal crops and their management practices. Methods of insect pest control. Classes of pesticides, their handling and safe use on seed crops.

UNIT IV

Storage insect pests infecting seeds, their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation.

UNIT V

Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures – domestic and commercial.

Practical

Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis- a- vis loss of seed quality. Safe handling and use of fumigants and insecticides ; safety measures in fumigating and disinfecting , exposure period, aeration etc. the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application.

Suggested Readings

Agarwal NA & Girish GK. 1977. *An Introduction to Action Programme to Regress on Farm Storage Losses in India*. FAO/NORAD Seminar on Farm Storage Grain in India, Nov. 29-Dec. 8, 1977.
Anderson JA & Aleock AW. 1954. *Storage of Cereal Grain & their Products*. American Assoc. Cereal Chemists, St. Pauls, Minn.

Objective

To provide understanding of the mechanism of seed ageing during storage, factors affecting it and its control.

TheoryUNIT I

Life span of seeds of plant species; classification of seeds on the basis of storage behaviour; orthodox and recalcitrant seeds; types of storage; kinds of seed storage (open, bulk, controlled, hermetic, germplasm, cryopreservation); soil seed bank; terminology; survival curve of seed.

UNIT II

Factors affecting seed storability- biotic and abiotic and pre- and post-harvest factors affecting seed longevity; the effects of packaging materials, storage fungi and insects, seed treatment and fumigation and storage environmental conditions on seed storability; moisture equilibrium in seeds; hysteresis effect; thumb rules; selection of suitable areas/places for safe storage; prediction of relative storability and longevity of seed lots, viability equations and nomographs.

UNIT III

Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and related theories; different changes associated with the loss of vigour and viability during storage; application of physiological and biochemical techniques for evaluation of seed ageing; genetics of seed viability; effect of seed ageing on crop performance; maintenance of viability and vigour during storage; seed amelioration techniques, mid storage corrections etc.

UNIT IV

Storage methods- requirement of storage facilities in India; types and storage structures available in the country and their impact on short and long term storage; methods of safe seed storage including eco-friendly techniques used in various group of crops viz. cereals, pulses, oilseeds, fibers, forages and vegetables; operation and management of seed stores; fruit storage; viability loss during transportation and interim storage.

Practical

To study the effect of storage environmental factors (RH, SMC and temperature) on seed longevity; to study the effect of packaging materials, seed treatment and fumigation on storability; prediction of storability and longevity of seed-lots by using viability equations and nomographs; standardization of accelerated ageing (AA) technique for assessing the seed storability of various crops; estimation of carbohydrates, proteins, fats, enzyme activities, respiration rate and nucleic acids in fresh and aged seeds; use of eco-friendly products and amelioration techniques to enhance quality of stored seeds, visit to seed stores.

Suggested Readings

- Barton LV. 1961. *Seed Preservation and Longevity*. Burgess Publ.
Basra AS. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Products Press.
Basra AS. 2006. *Handbook of Seed Science and Technology*. Food Product Press.

Theory

UNIT I

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Pre-requisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens; Sampling techniques

of plant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques (controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

Suggested Readings

- Briggs D. 1997. *Plant Variation and Evolution*. Science Publ.
- Cronquist AJ. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia Univ. Press.
- Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. *Germplasm Conservation A Compendium of Achievements*. NBPGR, New Delhi.
- di Castri F & Younes T. 1996. *Biodiversity Science and Development: Towards New Partnership*. CABI & International Union for Biol. Sci. France.
- Gurcharan Singh. 2004. *Plant Systematics: An Integrated Approach*. Science Publ.
- Lawrence GMH. (Ed.). 1951. *Taxonomy of Vascular Plants*. London.
- Paroda RS & Arora RK. 1991. *Plant Genetic Resources Conservation and Management Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.
- Pearson LC. 1995. *The Diversity and Evolution of Plants*. CRC Press.
- Singh BP. 1993. *Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management*. Indo-US PGR Project Management.
- Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy*. Science Publ.
- Stace CA. *Plant Taxonomy and Biosystematics* 2nd Ed. Cambridge Univ. Press.
- Takhrayan A. 1997. *Diversity and Classification of Flowering Plants*. Columbia Univ. Press.
- Wiersema JH. 1999. *World Economic Plants: A Standard Reference*. Blanca Leon.

SST 601

HYBRID SEED PRODUCTION

1+ 1

Objective

To provide a comprehensive knowledge and practical exposure to hybrid seed production in field crops and vegetables.

Theory

UNIT I

Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.

UNIT II

Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

UNIT III

Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines.

UNIT IV

Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

Practical

Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows/blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots etc.

Suggested Readings

- Basra AS. 2000. *Heterosis and Hybrid Seed Production in Agricultural Crops*. Food Product Press.
- McDonald MB & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- Singhal NC. 2003. *Hybrid Seed Production*. Kalyani Publishers.

SST 602

***IN SITU AND EX SITU CONSERVATION OF GERMPLASM* 2+1**

Objective

To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.

UNIT II

Chemical-biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein, isozymes etc, use of chromatography for analysis of secondary compounds etc.

UNIT III

DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties.

UNIT IV

Use of computer-based machine vision (MVT) for varietal identification and purity testing.

Practical

Chemical and biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, use of chromatography for analysis of secondary compounds.

Suggested Readings

Basra AS. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Product Press.

ISTA 2006. *Handbook of Variety Testing*. International Seed Testing Association, Switzerland.

SST 604 DUS TESTING FOR PLANT VARIETY PROTECTION 2+1

Objective

To provide a comprehensive understanding of DUS testing, its conduct and significance to PVP.

Theory

UNIT I

Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions; General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties; Protection of Plant Varieties and Farmers' Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003.

UNIT II

Criteria for protection of new varieties of plants; principles and procedures of Distinctness, Uniformity and Stability (DUS) testing; test guidelines, planting material, duration, testing options, varieties of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.

UNIT III

Assessment of DUS characters based on morphological, biochemical and molecular markers; statistical procedures; computer software for use in DUS testing; impact of PVP on growth of seed industry; practical exercise of DUS testing in rice, wheat, pearl- millet, maize, rose and cauliflower.

Practical

Morphological description of plant parts and plant; character expression and states, recording observation and interpretation of data; chemical tests and markers applicable for DUS tests and case study of selected crops.

Suggested Readings

- Chakrabarty SK, Prakash S, Sharma SP & Dadlani M. 2007. *Testing Of Distinctiveness, Uniformity And Stability For Plant Variety Protection*. IARI, New Delhi.
- Joshi AK & Singh BD. 2004. *Seed Science And Technology*. Kalyani.
- The Protection Of Plant Varieties And Farmers' Rights Act 2001. Bare Act With Short Notes 2006. Universal Law Publ.

SST 605

ADVANCES IN SEED SCIENCE RESEARCH

1+0

Objective

To provide knowledge on the advances in various aspects of seed science & their application in seed technology.

Theory

UNIT I

Physiological and molecular aspects of seed development and control of germination and dormancy; gene expression during seed development; desiccation and stress tolerance and conservation; prediction of seed dormancy and longevity using mathematical models; structural changes in membranes of developing seeds during acquisition of desiccation tolerance; dehydration damage and repair in imbibed seeds, seed biotechnology; genetic analysis and QTL mapping of germination traits; seed ageing and ethylene production; recent accomplishments in seed enhancement research and application of nanotechnology.

UNIT II

Modern techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fingerprinting and other molecular techniques and their utilization; techniques for improving seed quality; proteomic analysis; seed priming, coating, pelleting and synthetic seeds; GM seeds and their detection, terminator technology (GURT).

UNIT III

Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

UNIT IV

Seed production of self incompatible and apomictic plant species; recent developments in seed laws, policies and seed certification system in India and its comparison with OECD seed certification schemes; IPR systems and PVP internationally.

Suggested Readings

- Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.
- Black M & Bewley JD. (Eds.). 2000. *Seed Technology and its Biological Basis*. Sheffield Academic Press.
- Nicolas G, Bradford KJ, Come D & Pritchard HW. 2003. *The Biology of Seeds, Recent Research Advances*. CABI.

SEED SCIENCE AND TECHNOLOGY

List of Journals

- ❖ Crop Science
- ❖ Hort. Science
- ❖ Acta Horticultrae
- ❖ Indian Journal of Agricultural Science.
- ❖ Journal of Seed Technology
- ❖ Plant Varieties and Seeds
- ❖ Seed Abstracts
- ❖ Seed Research
- ❖ Seed Science & Technology
- ❖ Seed Science Research
- ❖ New Seed Journal
- ❖ Journal of Seed Production
- ❖ ISST News Bulletin

❖ e-Resources

- ❖ Ag Biotech Reporter www.bioreporter.com
- ❖ Agricultural Research Magazine www.ars.usda.gov/is/AR/
- ❖ American Seed Trade Association www.amseed.com
- ❖ Association of Official Seed Certifying Agencies www.AOSCA.org
- ❖ Association of Official Seed Analysts www.aosaseed.com
- ❖ Commercial Seed Analysts Association of Canada www.seedanalysts.com
- ❖ Front Range Seed Analysts www.frnsa.org
- ❖ International Seed Federation www.wordseed.org
- ❖ International Seed Testing Association www.seedtest.org
- ❖ International Society for Seed Science www.css.comell.edu/ISSS/iss.htm
- ❖ International Society of Seed Technologists www.isstech.org
- ❖ The Seed Biology web page at Cornell University
www.css.comell.edu/seedbio/seedbio.html
- ❖ Seed Biology at the Laboratory of Plant Physiology at the Wageningen University
www.wau.nl/uk/organisation
- ❖ The Ohio State Seed Biology webpage www.css.ohio-state.edu/%7Eseedbio/
- ❖ The Seed Biotechnology Center University of California <http://sbc.ucdavis.edu>
- ❖ Seed Viability and Storage Research Unit www.ars-grain.gov/ars/NoPlains/FtCollins/preservation.htm
- ❖ Seed World www.seedworld.com
- ❖ Seed Quest www.seedquest.com
- ❖ Seed Today www.seedtoday.com/info/ST_sites.html
- ❖ The South African National Seed Organization www.sansor.org/index.htm
- ❖ Society of Commercial Seed Technologists www.seedtechnology.net
- ❖ Wageningen Seed Centre www.seedcentre.nl

❖ Suggested Broad Areas for Master's and Doctoral Research

- ❖ Isolation distance requirements in view of GM varieties
- ❖ Review of seed certification standards
- ❖ GOT –seasonal requirements
- ❖ Genetic purity vis-a-vis trait purity
- ❖ Enhancement of pollen viability, stigma receptivity and seed setting
- ❖ Reduction of processing losses
- ❖ Alternate areas / protected cultivation methods for hybrid seed production
- ❖ Standardising processing needs in high value crops and forage grasses
- ❖ Protein and oil content in GM cotton seed and its effect on longevity
- ❖ Optimisation of hybrid seed production technology in field crops, vegetables and flowers
- ❖ Pollen collection methods and viability testing
- ❖ Management of seed borne diseases with biocontrol agents
- ❖ Seed enhancement for unfavorable conditions
- ❖ Identification of markers for hybrid confirmation and genetic purity testing
- ❖ GM seed testing
- ❖ Seed testing protocols and seed standards for forage crops, medicinal species and spices
- ❖ Molecular control of seed viability, vigour and invigoration
- ❖ Standardisation of priming, coating and pelleting technologies
- ❖ Development of technologies for maintenance of parental lines of SI and MS based hybrids
- ❖ Any other location specific problems

review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

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

PGS 503
(e-Course)

INTELLECTUAL PROPERTY AND ITS
MANAGEMENT IN AGRICULTURE

1+0

Objective

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

Theory

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

- Erbisch FH & Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC & Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.
- Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
- 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+1

Objective

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

Practical

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

Suggested Readings

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
- Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505
(e-Course)

**AGRICULTURAL RESEARCH, RESEARCH ETHICS
AND RURAL DEVELOPMENT PROGRAMMES**

1+0

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

Suggested Readings

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

PGS 506
(e-Course)

DISASTER MANAGEMENT

1+0

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches,

Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings

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

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