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CURRICULA AND SYLLABI FOR
MASTER'S DEGREE PROGRAMS

GENETICS AND PLANT BREEDING
AND
SEED SCIENCE AND TECHNOLOGY

ACCREDITATION BOARD SECRETARIAT
EDUCATION DIVISION
INDIAN COUNCIL OF AGRICULTURAL RESEARCH,
KRISHI ANUSANDHAN BHAVAN II, NEW DELHI-110 012

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Preface

The agricultural scenario in the post Green Revolution era has changed Indian agriculture from the subsistence farming to a commercial enterprise. Signing of World Trade agreement by India has exposed Indian farmers to the global competition. This demands rapid modernization of Indian agriculture so that our farm produce meets not only national but international quality standards, is produced at internationally competitive price and is sustainable. This, therefore calls for developing and imparting proper training to the farmers, which is possible only if the trainers which are produced by the agricultural universities are themselves properly educated in the advances in science of agriculture particularly at the post-graduate level where they have not only to learn the recent advances in their subject but have also to be trained in the modern and latest techniques in their disciplines so that they can participate and contribute in the development and advancement of agricultural science in India.

Keeping this in view, the ICAR which is vested with the responsibilities of guiding and coordinating agricultural education in the country, took several steps to ensure quality education to meet the ever changing national and global scenario in agriculture and allied sciences. One of these steps was to set up an Accreditation Board, which among other things is required to periodically assess the curricula of various educational programs offered by the National Agricultural Education System and suggest modifications.

The second step in this connection was the constitution of Broad Subject Matter Area (BSMA) Committees for modification of PG Curricula and related issues. The BSMA Committee on Plant Science was constituted through ICAR Office Order No. 1-3/98-Acdn./Edn. Dated 30.11.1998 to revise PG Curricula in Genetics and Plant Breeding, and Seed Science and Technology. The Committee comprised Dr S. Chandra Shetty, UAS, Bangalore; Dr P.L. Gautam, NBPGR, New Delhi; Dr S.N. Mishra, GBPUAT, Pantnagar; Dr B.D. Singh, BHU, Varnasi; Dr MMK Durga Prasad of ANGRAU, Dr N.C. Singhal, IARI, New Delhi and Dr B.S. Dhillon, ICAR, New Delhi with Dr K.R. Sarkar, IARI, New Delhi as Coordinator.

Though some of the members met informally and exchanged their views, formal meeting of the Committee could not be held. Therefore, Dr B.B. Singh, Head of Division, Genetics, IARI, New Delhi and Dr N.C. Singhal, Professor, Seed Science and Technology, IARI, New Delhi were identified

and requested to take lead in restructuring the PG curricula in respective disciplines. These identified Subject Matter Specialist took pains to compile the draft curricula based on the syllabi of leading institutions, both in India and abroad. The compiled curricula and course outlines were sent to different institution in India for their comments. The comments were analyzed and incorporated in the draft syllabi, which were discussed in separate workshops organized for the purpose and finalized. The workshop on Genetics and Plant Breeding was held at IARI, New Delhi on 27-28 April, 2001, which was attended by 39 Scientist (Appendix I). Similarly, the workshop on Seed Science and Technology was organized at NAARM, Hyderabad on 6-7 April, 2001, where 34 persons participated (Appendix-II).

The curricula and course outlines, which emerged from these workshops were placed before the Sectoral Committee of Accreditation Board on Curricula and Equivalence, which recommended the same to the Board for approval. The Board approved the curricula and course outlines in its 6th meeting held on 20th June,2001, which are brought out in this publication.

The students of Genetics and Plant Breeding are required to have in depth knowledge about classical and latest developments in the science of genetics, plant breeding and biotechnology. In modifying amd developing post-graduate course in Genetics and Plant Breeding, emphasis has been given to keep a balance among major components like basic genetics, cytogenetics, plant breeding, quantitative genetics, molecular biology and biotechnology. The courses in genetics include principles of genetics, gene regulation and genetic control of plant reproduction. Likewise, to cover the entire facets of cytogentics, the courses like principles of cytogenetics, crop cytogentics & genome analysis, and applied cytegentics were developed. Different courses have been designed in Plant Breeding to cover the basic principles, methodology for improvement of specific crops, stress resistance, quality improvement, mutagenesis, and population genetics. In Genetic Engineering and Biotechnology section, emphasis has been given on basic principles of genetic engineering, development of transgenic crops and molecular breeding. Due weightage has been given to practicals wherever it was felt necessary to provide opportunity to learn and do the exercises on topics covered in their classes.

In the earlier curriculum of Seed Science & Technology, there were different courses with similar titles and duplication of course contents in different courses. While restructuring postgraduate curriculum, these problems were overcome. Some of the courses of elementary nature were deleted and some advanced courses and emerging trends in seed quality enhancement containing new topics like pelleting, film coating, seed tape

mats, seed priming, synthetic seed, embryo encapsulation etc were added. New topics like IPR, PVP and molecular fingerprinting were also included in the curriculum. A new course on seed production in fruits and plantation crops, medicinal plants, and flowers was also added.

To bridge the gap between theory and practical and to give the best training to students, the workshop suggested an innovative approach for practical training in the form of student attachment with some seed industry/related organization. If this is implemented, this will be first new approach in post-graduate education in agricultural sciences.

We gratefully acknowledge the guidance and encouragement received from Dr R.S. Paroda, Secretary, (DARE) and DG, ICAR, and Chairman of Accrediation Board, in restructuring PG Curricula.

We sincerely thank Dr S.L. Mehta, the then DDG (Edn.) who took personal interest and guided the deliberations, particularly in Seed Science and Technology workshop. We also thank the members of the BSMA committee and Heads of Departments of Genetics and Plant Breeding, and Seed Science and technology from various agricultural universities, who sent their comments and suggestions, and specially to those who participated in respective workshops organized for the purpose. But for their help, the restructuring of curricula and course outlines would not have been possible.

We are grateful to Dr R.D. Singh, Dr S.K. Mishra and Dr A.K. Singh of the Genetics Division, IARI, New Delhi for their keen interest and valuable contribution in restructuring the syllabus of Genetics and Plant Breeding.

Special thanks are due to Dr Panjab Singh, Director, IARI, New Delhi and Dr J.C. Katyal, Director, NAARM, Hyderabad, who hosted the workshops on Genetics and Plant Breeding, and Seed Science & Technology respectively at their institutions.

We hope that this document will serve as a guide and help in achieving uniformly high standards of post-graduate education in the concerned disciplines. The Accrediation Board Secretariat will appreciate comments and suggestions for improving and updating this publication in future.

B.B. Singh
N.C. Singhal
N.L.Maurya

Contents

1. Genetics and Plant Breeding

A. MAJOR

A 1.	**Core Courses**		**12 Credits**
1.	Principles of Genetics	2+1	
2.	Principles of Cytogenetics	2+1	
3.	Principles of Plant Breeding	2+1	
4.	Principles of Quantitative Genetics	2+1	
Seminar		**0+1**	**1 Credit**
A 2.	**Optional Courses**		**8 Credits**
1.	Theory and Advanced Plant Breeding	2+0	
2.	Improvement of Field Crops	1+1	
3.	Heterosis Breeding	1+1	
4.	Breeding for Crop Quality	2+1	
5.	Bredding for Stress Resistance	2+1	
6.	Population Genetics	2+0	
7.	Molecular Genetics	2+0	
8.	Mutagenesis	2+1	
9.	Gene Regulation	2+0	
10.	Genetic Control of Plant Reproduction	1+1	
11.	Crop Cytogenetics and Genome Analysis	1+1	
12.	Applied Cytogenetics	2+1	
13.	Plant Genetic Resources	2+0	
14.	Genetic Engineering & Biotechnology	2+1	

B.	**SUPPORTING COURSES***		**14Credits**
1.	Elementary Statistics	2+1	
2.	Experimental Designs	2+1	

3.	Computer Applications in Agriculture	2+1
4.	Plant Tissue Culture	2+1
5.	Principles of Mycology and Plant Pathology	2+1
6.	Biochemical and Physiological Techniques	2+1
7.	Seed Production, Testing and Certification	2+1
8.	Library Information	1+0
9.	Instrumentation	1+0
	Total	**35 Credits**

*(i) Advisory Committee can include any other course as per the need of the students.

(ii) Course contents not given.

A 1. Core Courses

1. PRINCIPLES OF GENETICS (2+1)

Historical perspective on Genetics; Mendelian principles; Gene interactions; Linkage: detection and estimation in various organisms (viruses, bacteria, fungi and other eukaryotes); Multiple alleles; Mechanisms of sex determination; Sex-linked, sex-influenced and sex-limited traits; Intergenic and intragenic complementation and recombination, complex loci, fine structure analysis of gene; Genetic control of metabolism; gene-protein-polypeptide relationships; Genetic material: nature, organization, structure and replication; Genetic code transcription and translation; Gene regulation in prokaryotes; Gene regulation in eukaryotes - models, split genes, alternative splicing, transcriptional and post-transcriptional regulation etc.; Mobile genetic elements and dynamic nature of genome; Mutations: induction, detection and mechanisms; Environmental influence on gene expression; Extranuclear inheritance; Polygenic inheritance; Population genetics: Hardy-Weinberg equilibrium, changes in gene and genotype frequencies; Human genetics: genetic disorders and gene therapy; Introduction to recombinant DNA technology - restriction enzymes, vectors, genetic transformation and genomics.

Practical

Demonstration of Mendelian principles using Drosophila/plant systems; Modification of dihybrid ratios using maize as model system; Multiple alleles (ABO blood group system); Analysis of penetrance and expressivity (PTC test); Linkage and gene mapping using Drosophila/Neurospora; Numerical exercises related to Mendelian principles, gene interactions, Linkage and gene mapping; Induction and detection of sex-linked recessive lethals (Drosophila); Analysis of quantitative inheritance in plant (variation in seed weight); DNA Isolation and analysis of size variation among genomes (bacteria, phage and plants) and genomic components (chromosomal and plasmid DNA); Demonstration of molecular marker techniques.

Suggested Readings

1. Griffiths, A.J.F.; Miller, J.H; Suzuki, D.T.; Lewontin, R.C. and W.M. Gelbart(1996). An Introduction to Genetic Analysis. (6th Edition). W.H. Freeman, New York.

2. Jain, H.K. (1999). Genetics - Principles, Concepts and Implications. Oxford and 1BH Publishing Co. Pvt. Ltd., New Delhi.

3. Klug. W.S. and Cummings, M.R. 1983. Concepts of Genetics. Charles E. Merill Publishing Co., London.

4. Lewin, B.2000. Genes VII. Oxford University Press, New York.

5. Singh, B.D. 1990. Fundamentals of Genetics. Kalyani Publishers, Ludhiana.

6. Strickberger, M.W. 1996. Genetics (3rd edn.). Mac Millan Publishing Co., New Delhi.

2. PRINCIPLES OF CYTOGENETICS (2+1)

History of Cytogenetics, Chromosome structure: prokaryotes and eukaryotes, function and replication. Karyotype analysis, chromosome banding pattern and fine structure: Different forms of chromosomes and their functional significance. Lampbrush chromosomes, Polytene chromosomes, B chromosomes, Sex-chromosomes, Artificial chromosomes. Cell division; Mitotic cell cycle, chromosome cycle and chromosome movements; behaviour of chromosomes during meiosis, and its significance, mechanisms and theories of crossing over, recombination models, cytological basis and role of synaptonemal complex. Structural variation in chromosomes: their cytogenetical consequences, gene mapping and other uses-deficiences, duplication, inversions and interchanges. Numerical variation in chromosomes: Sources and consequences; euploidy and aneuploidy - classification, cytogenetics, segregation. Evolutionary significance and use in basic and applied research. Synthesis of natural and new polyploids, haplonitc-diplontic barriers and means to overcome them. Nucleocytoplasmic interaction; Chromosomes in evolution, Elements of molecular cytogenetics.

Practical

Preparation of important stains. Microscopy. Preparation of slides. Fixing of the materials for mitotic and meiotic analyses. Demonstration of crossing over/chiasmata. Karyotype analysis, chromosomal aberration, Chromosome banding, photomicrography and image analysis.

Suggested Readings

1. Gupta, R.K. 1999. Cytogenetics. Rastogi Publishers, Meerut.

2. Prasad, G. 1998. Introduction to Cytogenetics. Kalyani Publishers, New Delhi.

3. Sinha, U. and Sinha S. 1998. Cytogenetics, Plant Breeding and Evolution. Vikas Publishing House Pvt. Ltd., New Delhi.

4. Swaminathan, M.S., Gupta, P.K. and Sinha, U. 1974. Cytogenetics of Crop Plants. Mac Millan India Ltd., New Delhi.

5. Swanson, C.P., Merz, T. and Young, J. 1973. Cytogenetics. Prentice Hall of India Private Limited, New Delhi.

3. PRINCIPLES OF PLANT BREEDING (2+1)

Introduction to plant breeding-history, objectives, achievements in the pre-Mendelian era, post-Mendelian plant breeding, potential and opportunities.

Introduction, domestication and acclimatization. Patterns of evolution in crop plants, Centres of origin, gene pool concept - primary, secondary and tertiary gene pool, and gene introgression.

Plant genetic resources : Importance of plant genetic resources and diversity in plant breeding, collection, evaluation and conservation of germplasm.

Modes of reproduction in plants - asexual & sexual reproduction, self-and-cross-pollination mechanisms, male-sterility and self incompatibility.

Genetic bases of plant breeding : Genetic consequences of self and cross fertilization, genetics of self incompatibility. Mating systems - genetic & phenotypic assortative and disassortative matings and their genetic consequences; Qualitative & quantitative traits and their genetic behaviour in segregating populations; Components of variation, single gene and multiple gene concepts, epistasis and gene interactions; Heritability and genetic advance; Selection - responses to selection, selection differential, intensity and realized advance; Heterosis - concept and theories, inbreeding depression.

Methods of breeding self-pollinated, cross-pollinated and asexually propagated crops; Land races, pureline selection and mass selection; Pedigree selection, bulk method and its modification; Hybrid breeding, populations and population improvement, intra and inter population improvement; Clonal selection.

Mutation breeding, use of polyploidy and distant hybridization in plant breeding.

Mechanisms and genetic bases of resistance/tolerance to biotic and

abiotic stresses in plants, breeding for resistance/tolerance.

Application of biotechnology to plant breeding - embryo rescue, somaclonal variation, doubled haploidy, protoplast fusion, transgenics, molecular plant breeding, biosafety issues involved with genetically modified organisms.

Release and registration of new varieties, quality seed - classes, production practices and maintenance of pure seed, seed purity standards, UPOV convention and convention on biodiversity.

Practical

Floral biology in self and cross pollinating crop species; selfing and crossing techniques in major field crops; determination of extent of outcrossing, male sterility - detection & maintenance; self incompatibility and techniques of maintenance and overcoming sporophytic and gametophytic incompatibility; Selection methods in segregating populations, selection differential and intensity - demonstration of their relationship and effect on genetic gain; Evaluation of breeding material, screening for quality traits, resistance/tolerance to biotic & abiotic stresses; Demonstration of quality seed production through nucleus and breeders seed production techniques.

Suggested Readings

1. Allard, R.W. 1960. Principles of Plant Breeding. John Wiley & Sons, New York.
2. Hays, H.K., Immer, F.R. and Smith, D.C. 1955. Methods of Plant Breeding. McGraw Hill Book Company, Inc., New York.
3. Fehr, W.R. 1987. Principles of Cultivar Development (2 Volumes). Mac Millan Publishing Co., New York.
4. Poehlman, J.M. 1986, Breeding Field Crops. AVI Publishing Company, Connecticut.
5. Singh, B.D. 2000. Plant Breeding-Principles and Methods. Kalyani Publsihers, New Delhi.

4. PRINCIPLES OF QUANTITATIVE GENETICS (2+1)

Historical background on quantitative inheritance. Probability laws - expectation - fixed and random effect models - probability distributions, Elementary concepts of matrix theory - modulation of equation through matrix theory - linear models. Mendelian principles, - Gene and geno-

typic frequency. Partitioning of mean and variances. Single gene and multiple gene models - estimation of genetic parameters and scaling tests. Linkage, Epistasis, components of epistasis and their estimation, covariance between relatives. Inbreeding and heterosis - simple model extension to polygenic situations. Mating designs - diallel, North Carolina, line x tester designs and triple test cross. Concept of combining ability and relevance to gene action. Heritability, selection differencial and response to selection, correlated response, genotype x environment interaction, and stability analysis. Selection indices, path coefficient, genetic divergence, principal component and discriminate function analysis.

Practical

Probability laws, ANOVA fixed and random effect model, mean and variance in different populations (self, sib, backcross, F_2), partioning of total genetic variance in various models, analysis in North Carolina Designs, diallel, T.T. cross and L x T. Estimation of heritability, selection intensity, selection response. Correlation, regression, path coeffient and multivariate analysis. Use of computer package.

Suggested Readings

1. Comstock, R.E. 1996, Quantitative Genetics with Special Emphasis on Plant and Animal Breeding. Iowa State University Press, Iowa.
2. Falconer, D.S. and Mackay, J. 1996. Introduction to Quantitative Genetics, Longman Group Ltd., London.
3. Mather, K. and Jinks, J.L. 1971. Biometrical Genetics. Chapman and Hall, London.
4. Sharma, J.R. 1998. Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers, New Delhi
5. Singh, R.K. and Chaudhary, B.D. 1997. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi.

A2. OPTIONAL COURSES

1. THEORY AND ADVANCED PLANT BREEDING (2+0)

Components of variation and their estimation in single gene polygenes segregating populations, breeding values, additive and non-additive genetic components, epistatic components, variance components among early and advanced generation segregating populations, effective population size - their significance in decision making in plant breeding.

Selection theory : Types of selection, response to selection, selection advance, criteria of selection, selection limits, direct and indirect selection, multitrait selection and construction of selection index, correlated response.

Heterosis and genetic bases of heterosis; Prediction of heterosis, estimation and evaluation; F2 heterosis - genetic degeneracy consequences.

Breeding methods of self-pollinated crops : Pedigree and bulk selection and their genetic consequences, Grid selection (adoption of honey-comb, fan or other such designs) in breeding populations; Multiline- clean and dirty crop approach, genetic consequences, advantages and disadvantages; Recurrent selection and hybrid breeding.

Breeding methods for cross pollinated crops : Mass selection, recurrent selection and population improvement; Intra-population improvement-selection based on individual, family and combining ability; Inter-population improvement; Breeding composite and synthetic populations.

Hybrid breeding : Hybrids in self and cross pollinated crops - their genetic bases, heterotic pool concept; Development and improvement of heterotic pools and inbred lines, evaluation of inbred lines and hybrids; Production of hybrid seed - use of malesterility & its restoration mechanisms and genetic manipulation in hybrid breeding, apomixis in fixing heterosis.

Genetic characteristics of pure lines, inbreds, hybrids, clones, mixtures & multilines, composites and synthetics, their maintenance and multiplication.

Mating designs : Plant breeding applications, genetic component analyses through diallel, North Carolina designs, line X tester mating design and three-factor mating designs - covariances, genetic parameters, heritability, combining abilities, genetic parameters, heritability, progeny evaluation and parental selection, decision making options in development of breeding strategies for improvement of the target traits.

Genotype X Environment interaction : Analysis of variance over multiple environments, Stability models - Regression approaches, estimation of stability indices; Best linear unbiased prediction (BLUP).

Molecular marker assisted selection (MAS) : Types of molecular markers, their inheritance and mapping molecular markers, MAS for qualitative traits like abiotic and biotic stress resistance, Quantitative Trait Loci (QTLs) - Mapping QTLs, MAS for QTL improvement, Regression approach, single marker and multiple marker approach, interval-markers

approach, selection for combining ability through molecular markers.

Transgenic varieties - expression and variation in the transgenes, potential, concerns and relative advantages, biosafety issues of genetic implications.

Suggested Readings

1. Allard, R.W. 1960. Principles of Plant Breeding. John Wiley and Sons, New York.
2. Chopra, V.L. 1989. Plant Breeding (ed.). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
3. Fehr, W.R. 1987. Principles of Cultivar Development (Vol.2). Mac Millan Publishing Company Inc. New York.
4. Hays, H.K., Immer, F.R. and Smith, D.C. 1955, Methods of Plant Breeding. McGraw Hill Book Company Inc. New York.
5. Jenson, N.F. 1989. Plant Breeding Methodology. John Willey and Sons, New York.
6. Roy, Darbeshwar 2000. Plant Breeding - Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.

2. IMPROVEMENT OF FIELD CROPS (1 + 1)

Eminent Plant Breeders and their achievements; Breeding methods of specific crops like cereals (wheat, rice, barley, maize, sorghum and millets); pulses (gram, pea, lentil, pigeonpea, mungbean, cowpea and lathyrus); oilseeds (Brassica, soybean, groundnut), fibre crops (cotton, jute); forage crops (oat, berseem) and asexually propagated crops; National and international institutes for crop improvement.

Practical

Exposure of students to on-going breeding work of important crops. Collection and analysis of data on field trails.

Suggested Readings

1. Fehr, W.R. 1987, Principles of Cultivars Development (Vol. I). Mac Millan Publishing Company Inc., New York.
2. Hays, H.K. Immer, F.R. and Smith, D.C. 1955. Methods of Plant Breeding. McGraw Hill Book Company Inc., New York.
3. Poehlman, J.M. 1986. Breeding Field Crops. AVI Publishing Com-

pany, Connecticut.

4. Poehlman, J.M. and Borthakur, D.N. Breeding Asian Field Crops 1977. Oxford and 1BH Publishing Co., New Delhi.

3. HETEROSIS BREEDING (1+1)

Introduction-historical aspects; Development of heterosis concept, genetic, physiological and molecular basis of heterosis; Inbreeding depression; Hybrid breeding methodology-development and improvement of heterotic pool, and inbred lines, evaluation of inbred lines and hybrids, nature and number of testers, combining ability and performance per se, prediction of hybrid performance, BLUP, genetic diversity and heterosis, genotype & environment interaction and heterosis. Male sterility systems (cytoplasmic, genetic, cytoplasmic-genetic, EGMS, gametocide induced and genetically engineered male sterility) -origin, development, maintenance and exploitation in hybrid breeding; Application of biotechnology in heterosis breeding-molecular markers, doubled haploids, somatic hybridization; Current status and future prospects of hybrid breeding in selected crops (rice, wheat, mustard, sunflower, cotton, pearlmillet, sorghum, maize, pigeonpea, castor and vegetable crops).

Practical

Cytoplasmic male sterility systems in rice, wheat and Brassicas, somatic hybridization, identification of maintainers and restorers (wheat, rice and Brassica), estimation of heterosis, use of gametocides in male sterility induction, observations on floral traits promoting out-crossing, isolation requirements for hybrid seed production, demonstration of hybrid seed production on public and private farms.

Suggested Readings:

1. Banga, S.S. and Banga Sakhi K., 1998. Hybrid Cultivar Development. Narosa Publishing House, New Delhi.

2. Coors, J.G. and Pandey Shivaji, 1999. Genetics and Exploitation of Heterosis in Crops. American Society of Agronomy, Inc. and Crop Science Society of America, Inc.

3. Gowen, J.W. 1952. Heterosis. Iowa State College Press, Ames, Iowa.

4. Mukherjee, B.K. 1995. The Heterosis Phenomenon. Kalyani Publishers, New Delhi.

5. Rai, M. and Maurya, S.1995. Hybrid Research and Development. Indian Society of Seed Science and Technology, IAR1, New Delhi.

4. BREEDING FOR CROP QUALITY (2+1)

Quality traits in field crops-need and prospects for genetic improvement; Genetics of quality traits and their components: variability, correlation, heritability and association with yield; Breeding objectives, approaches and achievements in improvement of quality traits in specific crops; wheat - chemical composition of the grain, genetics and significance of storage proteins; evaluation of nutrition, cooking, ecological, baking & chapati making properties; Rice - chemical composition, genetics and evaluation of nutritional and cooking quality charaters viz. amylose, gelatinization temperature, gel consistency, kernel elongation ratio & aroma; Maize - properties of corn, starch speciality corn, high quality protein, biochemical and genetical studies of kernel mutants (opaque-2, floury 2 etc.); Fodder quality evaluation; Pulses - breeding for quality protein and genetic removal of antinutritional factors; oilseeds - Breeding for 0 - 0 Brassicas, low erucic acid & glucosinolates, high linoleic acid & oil content; Cotton-fibre quality components, seed processing and utilization.

Practical

Estimation of protein content in cereals and pulses; separation of glutenin subunits and determination of gluten strength in wheat; colourimetric estimation of amylose content and recording of cooking quality traits in rice; estimation of oil content in oilseeds; in vigtro and in vivo evaluation of fibre content; demonstration of cotton seed processing and ginning.

Suggested Readings:

1. Kent Jones D.W. and A.J. Amos. (1967). Modern Cereal Chemistry. 6th Edition. Food Trade Press Ltd., London.
2. Kent N.L. 1984. Technology of Cereals: An Introduction for Students of Food Science and Agriculture. 3rd Edition. Oxford Press. USA.
3. Millner, M. (1972). Nutritional Improvement of Food Legumes by Breeding. Proc. Symposium sponsored by PAG,FAO, Italy, 3-5 July 1972.
4. Olsson R.A. and K.J. Frey (Eds) 1987. Nutritional Quality of Cereal Grains. Genetic & Agronomic Improvement. American Science Association.
5. Romeran,. Y. (Ed) (1988). Wheat: Chemistry & Technology. St. Paul. Minnesota USA & American Association of Cereal Chemistry.
6. Salunkhe, D.K., J.K. Chavan, R.N. Adsule and S.S. Kadam. 1992. World Oilseeds - Chemistry - Technology & Utilization. Van Nostrand & Reinhold, New York.

7. Swaminathan, M.S., E.W. Spuague and Joginder Singh (Eds). 1982. Processing Utilization and Marketing of Maize. ICAR, New Delhi.

5. BREEDING FOR STRESS RESISTANCE (2+1)

Nomenclature and classification of stresses. Nature and importance of viral, bacterial, fungal and other diseases. Insect pests. Genetic, physiological and molecular mechanisms of disease and insect pest resistance. Host-parasite interaction - variation in pathogen and host, factors affecting host reactions, Gene-for-gene concept, implications and significance in plant breeding. Identification of resistance genes. Diversity and characterisation of pathogen variation. Multipathotype testing. Gene postulation using infection type data. Breeding for tolerance to abiotic stresses: moisture, salinity, alkalinity, water logging, temperature etc. Morphological, physiological and genetic basis of abiotic stresses.

Creation of artificial epiphytotics. Screening techniques for breeding materials. Sources of resistance, shuttle breeding, stability of resistance, gene deployment over time and space - Mechanism of durable resistance, breeding methods for disease resistance. Concepts of varietal blends, mixtures and multilines for stress resistance. Use of molecular markers in mapping genes for stress resistance. Molecular markers assisted selection. Introgression of genes from the wild relatives of crop plants. Pyramiding of resistance genes. Transgenics in management of biotic and abiotic stresses. Use of Bt toxins, protease inhibitors, lectins, chitinases and glucanases for insect pest management.

Practical

Demonstration of gene-for-gene interaction. Innoculation, isolation and establishment of pathogen e.g. Rusts of wheat, Blight in rice etc. characterization of race(s)/pathotypes using differential in various crop plants. Exposure of screening methods against insectpest of the region. Selection in stress environments, cration of artificial epiphytotic conditions.

- Creation of abiotic stress - pH, temperature induced stress and recording observations.
- Screening segregating populations.

Suggested Readings

1. Blum, A. 1988. Plant Breeding for Stress Environments. CRC Press, Florida.
2. Boyer, J.S. 1996, Advances in dought tolerance in plants. Advances in Agronomy 56: 187-218.

3. Ceccarelli, S., Acevedo. E., and Grando, S. 1991. Breeding for yield stability in unpredictable environments: Single traits, interaction between traits and architecture of genotypes. Euphytica, 56:169-185.

4. Garay B.R. and Branow J.R., 1988. Pollen selection for heat tolerance in cotton. Crop Sci., 28:857-859.

5. Levitt, J. 1980 Response of Plants to Environmental Stress: Water, Salt and Other Stresses. Academic Press, New York.

6. Rosielle, A.A., and Hamblin, J. 1981. Theoretical aspects of selection for yield in stress and non-stress environments. Crop Sci., 21:932-946.

7. Shannon, M.C. 1998. Adaptation of plants to salinity. Advances in Agronomy, 60:76-120.

8. Singh, K.N. 1995. Recent approaches to breeding for salt tolerance in crop plants. In: Proc. Genetic Research and Education: Current Trends & the Next Fifty Years. (Eds. B. Sharma et al.) Vol. I Indian Society of Genetics and Plant Breeding, New Delhi: 490-499.

9. Vijendra Das, L.D. 2000. Problems Facing Plant Breeding. CBS Publishers, New Delhi.

6. POPULATION GENETICS (2+0)

Foundation of theoretical population genetics. Hardy-Weinberg Law. Dynamics of gene frequency under selection, migration, mutation and genetic drift. Subdivision - selection in niches, small and pedigreed population. Linkage-equillibrium, Two and multi-gene systems. Polymorphisms and evolution, Inbreeding. Correlation between relatives. Mixed mating systems. Genetic load and fitness. Co-adapted gene complexes. Homeostasis. Adaptive organisation of gene pools. Introgression: case studies to illustrate various concepts of population genetics.

Suggested Reading

1. D.S. Falconer and J. Mckey. 1996. Introduction to Quantitative Genetics. Longman Group Ltd. London.

2. Hartl, D.L. and Clark, A.G. 1989. Principles of Population Genetics. Sinauer Associates, Massachusetts, USA.

3. Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, New York.

4. Li, C.C. 1982 Population Genetics. Iowa State University, USA.

5. Roy, D. 2000. Plant Breeding - Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.

6. Rao, C.R. 1952. Advanced Statistical Methods in Biometrical Research. John Wiley & Sons, New York.

7. MOLECULAR GENETICS (2+0)

Genomes in prokaryotes and eukaryotes; Genome organization - euchromatin and heterochromatin; DNA content variation; Types of DNA sequences - unique and repetitive sequences, VNTRs, minisatellites and microsatellites; DNA organization in eukaryotic chromosomes; Organelle genomes; Gene amplification and its significance; Mechanisms of DNA replication and recombination in prokaryotes and eukaryotes; DNA sequencing; gene fine structure in prokaryotes and eukaryotes; Split genes, alternative splicing, trans-splicing, pseudogenes, overlapping genes, nested genes (case studies); Transcription and its regulation - mechanisms in prokaryotes and eukaryotes, enhancers, suppressors, transcriptomes, transcription factors and their role; Post-transcriptional regulation - mRNA processing, SnRNAs, ribozymes and RNA editing; Regulation of protein synthesis in prokaryotes and eukaryotes - ribosomes, tRANs and translational factors; Post-translational modifications; Structural and functional genomics; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Mechanisms and regulation of cell division, cancer and cell ageing.

Suggested Readings:

1. Lewin, B. 2000, Genes VII. Oxford University Press, New York.
2. Brown, T.A. 1998. Genomes. John Wiley and Sons (East Asia), Singapore.
3. Alberts, B. et al 1994. 'Molecular Biology of the cell' 3rd Ed. Garland Publishing, New York.
4. Gupta, P.K. 1985. Genetics. Rastogi Publications, Meerut.
5. Jain, H.K. 1999. Genetics - Principles, Concepts and Implications. Oxfored and IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Klug, W.S. and Cummings, M.R. 1983. Concepts of Genetics, Charles E. Merrill Publishing Company, London.
7. Latchman, D.S. 1990. Gene Regulation - an Eukaryotic Perspective. Unwin Hyman Publication, London.
8. Singh, B.D. 1990. Fundamentals of Genetics. Kalyani Publishers, Ludhiana.

8. MUTAGENESIS (2+1)

History of experimental mutagenesis. Nature of mutations, spontaneous mutations: mode of induction. Physical mutagens: properties and effect of ionizing radiations, RBE and LET, direct and indirect effects. Chemical mutagens; nature of chemical reactions, mode of action and classification of various chemical groups. Transposons as mutagens, Somaclonal variation. Repair of mutagenic damage. Genetic sieves in mutation induction. Screening techniques and selection procedures of induced mutations; test systems. Modifying testers Biological and environmental parameters influencing mutagenic efficiency. Application methodology of mutagens and modification of their action. Specificity of mutation induction and directed mutagenesis; targeted gene replacement; gene silencing. Mutation breeding in plants, animals and microorganisms - scope and achievements. Use of mutagens as carcinostatic agents. Environmental mutagenesis - bacteria, mammalian cell cultures, Drosophila, transgenics as environmental mutagen monitors.

Practicals

Mutagenic treatment of seeds, pollen grains etc., analysis of M_1 generation, mitotic and meotic analysis. Gamma ray treatment of seed/Drosophila and detection of mutations. M_2 ananlysis. Studying the effects of modifying factors (water, pH, temperature) on mutation induction, mutation analysis (antibiotic resistance) in bacteria. Meiotic analysis of pollen grains.

Suggested Readings:

1. Auerbach, C. 1976. Mutation Research, Problems Results and Perspectives. Chapman and Hall, London.
2. Drake, J.W. and Koch, R.E. 1976. Mutagenesis. Dowden Hutchinson and Ross, Inc., U.S.A.
3. Siddiqui, B.A. and Khan, S. 1999, Breeding in Crop Plants - Mutations & In Vitro Mutation Breeding. Kalyani Publishers, New Delhi.
4. Micke, A. 1991. Induced Mutations for Crop Improvement. Gamma Field Symposia No. 30. Institute of Radiation Breeding, Pullman, USA.
5. IAEA. 1991. Plant Mutation Breeding for Crop Improvement. Proc. FAO/IAEA Symposium (Vol. 1&2). IAEA, Vienna.
6. IAEA, 1995. Induced Mutations and Molecular Techniques for Crop Improvement Proc. FAO/IAEA Sympoium, Vienna.

9. GENE REGULATION (2+0)

Gene regulation in prokaryotes and eukaryotes - and introduction; Organisation of nuclear, mitochondrial and chloroplast genes; Structure, organisation and regulation of nuclear genes. Repetitive sequences and their significance, Coordinate and combinatorial gene regulation; Transposons and their influence on gene expression; Spatial and temporal control of gene expression; Homeotic genes in organ identity; Chloroplast gene expression and genes involved in photosynthesis. Mitochondrial genome and control of plant fertility; Intercation among nuclear, mitochondrial and chloroplast genomes. Epigenetic phenomena - paramutation, genome inprinting, DNA methylation, gene silencing; Genes responding to hormones, biotic and abiotic stresses; signal transduction. Functional genomics and proteomics. Plant-microbe interaction. Plant genomics and genetic engineering and their future prospects.

Suggested Readings

1. Alberts B; J. Lewis; Raff, K. Roberts and J.D. Watson 1994. Molecular Biology of the Cell. 3rd Ed. Garland Publishing, New York.
2. Howell, S.H. 1998. Molecular Genetics of Plant Development. The Cambridge Univ. Press, Edinburgh.
3. Karp, A. et al. 1997. Molecular Tools in Plant Genetic Resources Conservation: A Guide to the Technologies. IPGRI Technical Bulletin No.2. International Plant Genetic Resource Institute, Rome.
4. Peterson, P.A. 1987. Mobile Genetic Elements in Plants. CRC Critical Reviews on Plant Sciences, 6:105-208.
5. T.A. Brown 1999. Genomes. John Wiley & Sons. New York.

10. GENETIC CONTROL OF PLANT REPRODUCTION (1+1)

Pollination mechanism and fertilization process and its analysis: Genetics and molecular biology of male and female gametes. Anther and ovule development. Pre- and post-fertilization barriers in wide crosses - principles and techniques to overcome fertitlity barriers; In vivo and in vitro fertilization mechanisms and its applications for crop improvement; Male sterility - types and mechanisms - methods of inducing male serility in crop plants. Anther specific genes and their utility in developing male sterility. Pollination mechanisms and their evolution. Gene-flow studies in relation to transgenics. Self-incompatibility - cellular, genetic and molecular basis male genetophytic selection and its application. S gene - structure and function (case studies: tomato, Brassica, tobacco). Somatic hybridization in crop plants. Apomixis - mechanism forms and

applications. Limitations, progress and prospects of transfer of apomictic trait to crop plants. Haploid parthenogenesis - induction, detection and uses.

Practical

Floral features (syndromes) in relation to mode of pollination. In vitro pollination. Pollen preservations and viability test. Test for stigma receptivity. Anther, ovule and overy culture techniques. Pollen germination techniques - in vitro & in vivo study of fertility barrier in wide hybridization and demonstration (wheat, peas, Brassica, cotton). Dissection of different stages of embryo development in monocots and dicots. Embryo rescue technique.

Suggested Readings

1. Kual, M.L.H. 1988. Male sterility in Higher Plants. Springer-Verlag, Berlin.
2. Nettan Court D. de. 1977. Incompatability in Angiosperms. Springer - Verlag, Berlin.
3. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, U.K.
4. Richards A.J. 1997. Plant Breeding Systems (2nd Edition). Chapman & Hall, London.
5. Shivanna, K.R. and Sawhney, V.K. 1977. Pollen Biotechnology in Crop Production and Crop Improvement. Cambridge Univ. Press. U.K.
6. Wyatt, R. 1992. Ecology and Evolution of Plant Reproduction. Chapman & Hall, London.

11. CROP CYTOGENETICS AND GENOME ANALYSIS (1+1)

Principles and procedures of genome analysis, colinearity among genomes and synteny, use of conventional and modern techniques - morphological, cytological, genetical, biochemical and molecular tools. Species concept: theories of evolution, isolation mechanisms and criterion of species, Major crop plants of India, their distribution and centres of diversity. Role of cytogenetical factors in the evolution of major crops like wheat, rice, maize, sugarcane, Brassica, cotton, jute, tobacco, potato, tomato, pulse crops, forage crops and cucurbits.

Practical

Genome analysis based on morphological traits. Chromosome pairing in intergeneric and interspecific hybrids. Chromosome banding (C, Q, N, G,) in Secale, Triticale maize and onion. Production of haploids through intergeneric crosses, embryo rescue, and double haploids using colchicine. Evolutinary trends in crop plants e.g. rice, wheat, cotton, Brassica etc.

Suggested Readings

1. Dobzhonsky, T. 1964. Genetics and the Origin of Species (Indian Edition). Oxford Book Co., New Delhi.
2. Gupta, P.K. 1999. Cytogenetics. Rastogi Publishers, Meerut.
3. Khush, G.S. 1973. Cytogenetics of Aneuploids. Academic Press, New York & London.
4. Jauhar, Prem P. 1996. Methods of Genome Analysis in Plants. CRC Press, Canada.
5. Poehlman, J.M. and Borthakur, D.N. 1977. Breeding Asian Field Crops. Oxford & IBH Publishing Co., New Delhi.
6. Simmonds, N.W. 1984. Evolution of Crop Plants. *Longman,* U.K.
7. Swaminathan, M.S., Gupta, P.K. and Sinha, U. 1974. Cytogenetics of Crop Plants. Mac Millan, India Ltd., New Delhi.

12. APPLIED CYTOGENETICS (2+1)

Application of cytogenetical methods for plant improvement. Location and mapping of genes on chromosomes: Deficiency method. Interchange - genetic consequence, identification of chromosomes involved, balance lethal systems, its maintenance and utility, all arms marker method. Multiple interchange - use in producing inbreds, transfer of genes, linked marker method. Inversions for location of genes, Trisomics - different types, production, breeding behaviour and location of genes balanced teritiary trisomics - use in hybrid seed production. Monosomics - methods of production, intervarietal substitutions, allelic and non-allelic interactions. Telocentric method of mapping. Relative efficiency of different methods. Application in crop improvement: Duplications - production and use. Polyploid methods, use of auto-polyploids. Haploidy - methods of production and use. Gene transfer by distant hybridization: scope and limitation, methods to overcome barriers - tissue culture. Allopolyploids - synthesis of new crop species and varieties. Alien chromosome addition and substitutions. Chromosomal control of meiotic

pairing and induced transfer of alien genetic variation. Molecular cytogenetic techniques and their applications.

Practical

Cytogenetical analysis of mitotic and meiotic chromosomal abberrations. Maintenance of aneuploid stocks and location of genes on specific chromosomes. Study of secondary chromosome association. Chromosome pairing. Chiasma frequency in monosomic, trisomic, disomics, interspecific and intergeneric hybrids. Demonstration of multiple interchanges, B-A translocations and their uses. Cytological analysis of haploids (maize as a model crop). Analysis of chromosome pairing in wheat and rye hybrids, pachytene analysis. Maintenance of aneuploid stock.

Suggested Readings

1. Burnham, C.R. 1964. Discussions in Cytogenetics. Burgess Publishing Company, Minnensota (USA).
2. Khush, G.S. 1973. Cytogenetics and Aneuploids. Academic Press Inc., New York.
3. Ramage, R.T. 1991. In: Gupta P.K. and Tsuchiya T. (eds). chromosome Engineering in Plants: Genetics, Breeding and Evolution, Part A. Elsvier, Amsterdam: 385-400.
4. Jauhar, P.P., 1996. Methods of Genome analysis in Plants. CRC Press, Canada.
5. Sears, E.R. 1954. Missouri Agri. Exp. Stat. Res. Bull. 572.
6. Weberl, D.F. 1991. In: Gupta P.K. and Tsuchiya T. (eds). Chromosome Engineering in Plants: Genetics, Breeding and Evolution, Part A. Elseevior, Amsterdam: 181-210.

13. PLANT GENETIC RESOURCES (PGR) (2+0)

Historical perspective; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and diversity; Basic genetic resources, derived genetic resources and transgenes; 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; Germplasm conservation - in situ, ex situ and on-farm; short -, medium -, long -term conservation strategies for conservation of orthodox and non-orthodox seed, vegetatively propagated crops; registration of plant genetic resources; PGR data base

management, description, national and international mechanism for PGR management; Plant genetic resources for food and agriculture (PGRFA), PGR access and benefit sharing; IPR, PBR, UPOV and CBD issues and consequences; Farmers' rights and privilege; Visti to Gene Bank/National/Regional Research Centres.

Suggested Reading

1. Gautam. P.L., Dabas, B.S., Srivastava, U and Duhoon, S.S. (eds.), 1998. Plant Geermplasm Collecting Principles and Procedures, NBPGR Publication, NBPGR, New Delhi.
2. Gautam, P.L., Sharma, G.D. Srivastava, U. Singh, B.M., Ashok Kumar, Saxena, R.K. and Srinivasan, K. (eds.), 2000. 20 Glorious Years of NBPGR (1976-1996). National Bureau of Plant Genetic Resources, New Delhi.
3. Paroda, R.S. Arora, R.K. and Chandel, K.P.S. (eds.). 1988. Plant Genetic Resources; Indian Perspective, NBPGR, New Delhi.
4. Rana, R.S., Singh, Bhag, Koppar, M.N., Rai, M., Kochar, S. and Duhoon, S.S. (eds.) 1994. Plant Genetic Resources: Exploration, Evaluation and Maintenance, NBPGR, New Delhi.
5. Singh, B.B., Singh, N. and Srinivasan, K. (eds.), 1997. Practices and Procedures in Germplasm Conservation. NBPGR Publication, NBPGR, New Delhi.

14. GENETIC ENGINEERING AND BIOTECHNOLOGY (2+1)

Introduction to plant genetic engineering and biotechnology, gene identification, gene isolation, synthesis of genes and gene cloning. Restriction enzymes and vectors. Regeneration in crop plants. Gene transfer systems-vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique. Selectable markers and reporter system. Application of Plant Genetic Engineering and biotechnology - Transgenic crops - application of recombinant DNA technology - current status and future prospects. Regulation mechanism for genetically modified crops. Biosafety issues of transgenic crops. Molecular Breeding - morphological, biochemical and DNA based markers (RFLP, RAPD, AFLP, SSLP etc.); Mapping populations (F2s, backcrosses, RILs, NILs and DHs). Molecular mapping and tagging of agronomically important traits. QTLs analysis in crop plants. Marker assisted selection for qualitative and quantitative traits. Gene pyramiding. Biotechnology application in male sterility/hybrid breeding. Embryo rescue, somatic hybridization and doubled haploids. Biotechnology in PGR management.

Practical

In vitro techniques, nuclear, plasmid and bacteriophage DNA isolation, Demonstration of in vitro regeneration. Demonstration and practice of important biotechnological techniques and transformation, isozyme analysis, molecular marker analysis using PCR technique, DNA finger-printing, molecular marker and mapping population, visit to laboratories.

Suggested Reading

1. Caetano - Anolles, G. and Gresshoff, P.M. 1997 - DNA Markers: Protocols Applications and Overviews. WILEY - VCH, New York, USA.
2. Liu Ben Hui. 1998. Statistical Genomics: Linkage, Mapping and QTL Analysis. CRC Press LLC, Florida, USA.
3. Natesh, S., Chopra, V.L. and Ramachandran, S. (Eds.), 1987. Biotechnology in Agriculture. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Old, R.W. and Primrose, S. B. 2001. Principles of Gene Manipulation: An Introduction to Genetic Engineering 5th Edition. Blackwell Science Ltd., USA.
5. Wennacker, Ernst L. 1987. From Genes to Clones: Introduction to Gene Technology. VCH Publishers, Weinheim (Federal Republic of Germany).

2. Seed Science and Technology

A. MAJOR

A.1. CORE COURSES		**12 CREDITS**
1. Floral biology, seed development and maturation	1+1	
2. Principles of seed production	2+2	
3. Seed testing and quality control	2+1	
4. Sedd health management	2+1	
Seminar	**0+1**	**1 Credit**

A.2 OPTIONAL COURSES		**12 CREDITS**
*1. Seed processing and storage	2+1	
2. Plant quarantine	1+0	
3. Seed pathology	1 + 1	
4. Seed entomology	1 + 1	
5. Seed physiology	2+1	
6. Cultivar purity testing	1 + 1	
7. Seed production in forage and pasture crops	1 + 1	
8. Seed production in vegetable, flower and medicinal plants	2+1	
9. Emerging trends in seed quality enhancement	1 + 1	
10. Seed production in fruits and plantation crops	2+1	

B. SUPPORTING COURSES **10 CREDITS**

To be decided by the Students Advisory Committee

Total: 35 Credits

*As per the suggestion during the Workshop course number 1 under optional should be taken by all students of Seed Science and Technology.

INNOVATIVE APPROACH*

During the course of discussion the group felt the need of practical training/attachment of students at PG level. It was observed that the students are not performing well in the industry when they take up employment after post-graduation. Dr. Saha too drew the attention of the house about the practical training of the students in agri-bussiness houses as is being practiced in management courses. Dr. Singhal informed the house about the pattern of practical training which is being followed in IIM. Indore which is being appreciated by students and the stake holders. In IIM, Indore it is obligatory for every student to visit the factory once in a week for learning by doing and this has been incorporated as a new subject i.e. Experimental Learning. Similarly, Indo-German Chamber of Commerce is offering MBA course based on Duel System of Education which is an integration of theory and practice. During the course of discussion the group felt that though the students after passing M.Sc. degree are sound in theory but find it difficult to implement the theoretical knowledge. To bridge the gap between theory and practical and to give best training to the students and group took following innovative decision in which Dr. S.L. Mehta, Dr. S.N. Saha and Dr. N.L. Maurya also took active part.

(a) Student will complete 25 credits in taught courses in first two semesters.

(b) In the third semester he/she will be attached with public/private seed companies, certification agencies or govt. seed production farms. During this semester he/she will work with regular employees of that organization. The evaluation of the student may be by written test in the area in which the student is attached. His/her performance in the organization will be evaluated jointly by the faculty and the identified supervisor of the organization. Implementation details may be worked out after it is approved by the Council. This attachment will be of 10 credits from among the optional courses under major.

(c) Fourth semester will be for research project.

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* Till this pattern is approved by the Accreditation Board, universities may offer M.Sc. program in Seed Science and Technology like any other M.Sc. program.

A.1. CORE COURSES

1. FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION

1+1

Flower type, floral structure in relation to seed development. Microsporogenesis and megasporogenesis. Development and structure of megasporangium, microsporangium. Gametogenesis: male and female gametophyte development and structure. Pollination mechanism and control of pollination. Fertilization: barriers to fertilization, incompatibility and male sterility. Embryogenesis: development of typical monocot and dicot embryo. Endosperm development, modification of food storage structures with reference to crop plants. Different types of embryo, endosperm and cotyledons, development and structure in representative crop plants with reference to food storage. Seed structure: external and internal features of monocot and dicot seed. Seed maturation. Apomixis - classification, significance and its utilization in different crops for hybrid seed production. Polyembryony: types and significance. Seed-coat structure and development in representative crop plants. Seed-coat permeability. Seed sterility and its causes, haplontic and diplontic sterility. Causes of embryo abortion.

Practical

Study of floral biology of monocot and dicots. Seed-coat: its structure, texture in relation to permeability, imbibition of water. Heterostyly. Micro and megasporogenesis. Pollen morphology, pollen germination and pollen sterility. Monocot and dicot embryos. External and internal structure of monocot and dicot seeds. Maturity indices.

Suggested Readings

1. Bewley, J.D., and L. Black. 1982. Physiology and Biochemistry of seeds in relation to germination, Vol.1 and Vol.11, Springer-Verlag, Berlin Heiderbe, New York.
2. Jaima Kigel, J. and G. Galili, 1997. Seed development and germination, Marcel Dekker, New York.
3. Kha, A. 1977. The Physiology and Biochemistry of seed dormancy and germination, NOrth Holland Publishing Co., Amsterdam, New York.
4. Kozlowski, T.T. 1972. Seed Biology, Vol. 1, Academic Press, London.

2. PRINCIPLES OF SEED PRODUCTION 2+2

Seed industry development. Classification of crop plants in relation to mode of reproduction, Variety: definition, type, development, release system and notification. Objectives of seed production, generation system. Factors affecting seed production; site selection; isolation and roguing; compact area approach. Variety maintenance, nucleus and breeder seed production in different crop groups. Hybrid seed production; heterosis; inbreeding depression; genetic, physiological and biochemical basis of heterosis. Two and three-line system of hybrid seed production. Development of A, B and R lines. Male sterility, its kind and use in hybrid seed production. Self-incompatibility, its genesis and use in hybrid seed production. Gametocides. Seed production planning.

Practical

Seed production planning in different crops with special reference to land and isolation requirements. Agronomic management, roguing, harvesting and threshing. Characters of important varieties and its maintenance. Nucleus, breeder, foundation and certified seed production in crops like wheat, rice, potato, chickpea, lentil and mustard.

Seed production planning in cross pollinated crops with special reference to land and isolation requirements, planting ratio of male and female parental lines, synchronization between male and female parental lines, methods to achieve synchronization, pollen collection, supplementary pollination, pollen storage, hand pollination in sunflower, hand emasculation and pollination in cotton, tomato and cucurbits, identification of male and female flowers in castor and its seed production management. Roguing. Detasselling, pollination in corn, pollen shedders identification. Gametocide application and observation of results, pollen collection, storage, viability and stigma receptivity. Application of GA_3 and supplementary pollination in hybrid rice. Visit to seed production plots of corn, pearl millet, sorghum, sunflower, castor, cotton and pigeonpea.

Suggested Readings

1. Anon, 1997. Seed Technology in Tropics. ISTA Zurich.
2. Desai. B.B., P.M. Kotecha and D.K. Salunkha. 1997. Seeds hand book biology, production, processing and storage. Marcel Dekker. New York.
3. Sinclair, T.R. and F.P. Gardner, 1977. Principles of Ecology in Plant production, CAB international, G.K.
4. Rai, M. and S. Mauria, 1995. Hybrid Research and Development. Indian Society of Seed Technology, IARI, New Delhi.

5. Agrawal, R.L. 1996. Seed Technology, IBH publishing Co., New Delhi.
6. Feistrizer, P. and A.F. Kelly, 1978. Improved seed production, FAO, Rome.
7. Habblethwaite, P.D., 1980. Seed production, butter worths, London-Boston, Sydney Wellington-Durban Toronto.
8. Banga, S.S. and Banga, S.K. (1998). An introduction in hybrid cultivar development. Narosa Publ. House, New Delhi.
9. Mukherji, B.K. (1995). The heterosis phenomenon Kalyani Publ. New Delhi.

3. SEED TESTING AND QUALITY CONTROL

National and international history of seed testing. Seed testing network in India. National and international seed testing rules. Seed testing organizations. Seed sampling, heterogeneity test. Sample receipt and registration. Physical purity analysis. Determination of other seeds by number and determination of other distinguishable for different crops, seedling evaluation. Moisture test. Tetrazolium test - principles, procedure and evaluation. Testing for coated/pelleted seeds. Testing for varietal verification, grow-out test. Seed health. Insect damage. Reporting of seed testing results. Laboratory layout, furnishing and management. Variability in seed testing results, factors affecting variability, use of tolerance tables in seed testing. Sequential sampling analysis. Seed dormancy, types and methods to break it. Weed seed identification. Preservation and storage of guard samples.

History of seed quality control. Importance of good quality seed. Seed quality standars - definition and concept. Seed quality components and field standards. Concept and purpose and phases of seed certification. Certification agency. Variety eligibility, class and sources of seed, verification of seed source. Unit of certification, field inspection and reporting of results, comparing field observations with minimum standards, grow-out test, tolerance levels. Seed analyst and his duties. Laboratory evaluation and packaging, seed lot size and construction of seed lot number, certified seed label, certification tag, validity period of certification. Seeds Act and seed rules and law enforcement. Seed control order. Seed policy. Seed inspectors-powers and duties, inspection procedures and equipments required.

OECD- role of OECD in standardizing the seed certification procedures. UPOV- role of UPOV in international seed trade. Consumers Protection Act. Weights and Measures Act and Packaging Act.

Practical

Sampling and submission of samples to seed testing laboratory, sample registration, determination of the relative efficacy of various mixing and dividing techniques, obtaining working sample, physical purity analysis and reporting results. Testing of the germination substrata and determination of substrate quality, and reporting results. Methods of breaking drmancy, Tetrazolium test. Moisture test- oven method, moisture meters. Visit to state seed testing laboratory, Determination of ODV.

Field inspection at different crop growth stages- taking field counts in different crops. Offtypes,pollen shedders, designated seedborne diseases, counts of the male and female parents in hybird seed production, field inspection report for different crops, field area measurements, isolation distances.

Suggested Readings

1. Agrawal, P.K., and M. Dadlani, 1987. Techniques in Seed Science and Technology, South Asian.
2. Agrawal, R.L. 1996. Seed Technology, Oxfored & IBH, Publishing Co., New Delhi.
3. Anon 1965. Field Inspection Manual and Minimum Seed Certification Standars, NSC Publications, New Delhi.
4. International Seed Testing Association, 1979. Hank book of seedling evaluations, Scientific Publishers, Jodhpur.
5. International Seed Testing Association, 1987. Hand book of pure seed definitions, Scientific Publishers, Jodhpur.
6. Martin, C. and D. Barkley, 1961. Seed identification manual, Oxford, IBH Publishing Co., Calcutta.
7. Mc Donald, M.B. and L.O. Copeland, 1997. Seed Science and Technology Laboratory Manual, Scientific Publisher, Jodhpur.
8. Nema, N.P. 1987. Principles of Seed Certification and Testing, Allied Publishers Pvt. Ltd., New Delhi.
9. Tunwar, N.S., and S.V. Singh, 1988. Indian Minimum Seed Certification Standards, Central Seed Certification Board, New Delhi.

4. SEED HEALTH MANAGEMENT 2+1

Historical development of seed health testing and significance of seedborne diseases and insect pests. Important storage pests namely seedborne plant pathogens (fungi, bacteria, viruses, viroids, nematodes),

insects, mites, rodents and birds associated with seed under field and storage conditions. Detection of seedborne pathogens and insects. Deterioration of seed due to storage fungi, insects, rodents, birds. Detection of damage and estimation of losses, conditions favouring various storage pests. Pest development and control. Management of insect pests, mites, rodents and birds through seed treatments (biological, chemical, physical and mechanical). Seed certification and plant quarantine.

Practices for safe storage, examination of seeds for infection. Washing test, incubation method. Seedling symptomatology test. Histopathology. Embryo Count method. NaOH seed soak method. Immunoassays and nucleic acid based techniques. Collection and identification of storage insect pests. Dose estimation of various seed protectants, methods of fumigation, fumigants, its safe handling and use, plant protection equipments and their use.

Practical

Examination of seeds for infections. Washing test. Incubation methods. Seedling symptomatology test. Histopathology. Embryo count method. NaOH seed - soak method. Immunoassays and nucleic acid based techniques. Collection and identification of storage pests. Dose estimation of various seed protectants. Methods of fumigation, fumigants, its safe handling and use. Plant protection equipment and their use.

Suggested Readings

1. Desai, B.B., P.M. Kotecha and D. K. Salunkha 1997. Seeds hand book, Published by Mercel Dekker INC, New York.
2. Mather, S.B. and K.N. Mortensen, 1997. Seed health testing in the production of quality seeds. ISTA, Zurich.
3. Neergaard, P. 1997. Seed pathology. Macmillan Press Ltd., London.

A.2 OPTIONAL COURSES

1. SEED PROCESSING AND STORAGE 2+1

Introduction and importance of seed processing. Different methods of seed drying, including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed. Preparing seed for processing: scalper debearder, scarifier, huller, seed cleaner and grader, screen cleaners, specific gravity separators, indented cylinder, separator, velvet separator, spiral separator, disc separator, colour

sorter. Seed treatments-methods of seed treatment, seed treating compounds, sed disinfestations. Packaging: principles and practices and materials. Processing plant design and layout. Delinting machines. Seed storage: importance and factors affecting it, chantges during storage, concepts and significance of moisture equilibrium, method of maintaining safe seed moisture content. Thumb rule and its relevance, loss of viability in important agricultural and horticultural crops, viability equation and nomograph. Conservation of orthodox and recalcitrant seeds. Methods to minimize the loss of seed vigour and viability. Storage losses due to pests. Factors influencing storage losses. Storage methods and godown sanitation. Storage structure. Storage pests and their control.

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 processing equipment. Seed treating equipments. Seed extraction. Visit to seed processing plant. 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 AAT/controlled deterioration.

Suggested Readings

1. Agrawal, R.L. 1996. Seed Technology. Oxford publication, New Delhi.
2. Barton, L.V. 1985. Seed preservation and longevity, International Books and Periodicals supply service, New Delhi.
3. Justice, O.L. and L.N. Bass, 1978. Principles and practices of seed storage, Castle House Publications Ltd., Great Britain.
4. Koslowski, T.T. 1972. Seed Biology, Vol. III, Academic Press, New York and London.
5. N.R. Brandenberg, 1961. Why and how are seeds dired? The year book of Agriculture, USDA, Washington, D.C., P. 295.
6. R.K. Mathews, G.B. Welch, J.C. Delouche and G.M. Dougherty, 1969. Drying, processing and storage of corn seed in tropical and subtropical regions, Proc. Am. Agric. Eng. St. Joseph, Mich. Paper No. 69-67. 1969.

2. PLANT QUARANTINE 1+0

History and significance of plant quarantine. Principles, scope and pros-

pects of plant quarantine, plant quarantine operations in India. New seed policy in India with reference to plant quarantine. Role of plant quarantine in preventing and checking the spread of insects, plant pathogens, viruses and weeds, nematodes and alien genes. Multilateral agreement for the movement of transgenics; Domestic and international quarantine, its weaknesses and measures for its strengthening. Plant protection convention and international cooperation in plant quarantine. Pest risk analysis. Problems in assessing the overall effectiveness of plant quarantine. Techniques for the detection of insects, mites, nematodes, fungal, bacterial pathogens and viruses. Salvaging the germplasm. New exim policy. Plant quarantine authority.

Suggested Readings

1. Containment facilities and safeguards for exotic plant pathogens and pests. (ed. R.P. Khan & S.B. Mathur). American Phytopathological Society. 1999.
2. Plant quarantine and genetic resources management. (ed. R.S. Rana, Ram Nath, R.K. Khetarpal, Nandini Gorte and I.S. Bisht). NBPGR, New Delhi, 1993.
3. Seed Pathology Vol. I & II P. Neergaard. Macmillan Press London. 1979.
4. Sharma, K.D. Usha Dev and Ram Nath (1990). Plant pathogens not known to occur in India. NBPGR, New Delhi. p. 87.

3. SEED TECHNOLOGY

Terminology, significance and historical development. Seed structure and development in relation to infection and infestations. Mechanism of seed infection, factors affecting seed infection. Seed transmission and factors affecting seed transmission of pathogens. Logevity of seedborne pathogens. Epighytology of seedborne diseases. Nonparasitic seed disorders. Deterioration of seeds by storage fungi, mycotoxins and mycotoxicosis. Detection of seedborne pathogens. Control of seedborne pathogens. Selection of seed production areas. Crop management. Seed treatment (biological, chemical, physical and mechanical). Seed certification and plant quarantine.

Practical

Techniques of seed health testing: immunoassays, nucleic and based techniques, isolation and identification, sterilization and media preparation, visual examination of seeds, seed washing test, incubation meth-

ods, embryo count method, seed soak method for the detection of certain seedborne pathogens.

Suggested Readings

1. Hanson E.W., Hansing and W.T. Schroeder 1961. Seed treatments for control of diseases, Seeds: The Yearbook of Agriculture, USDA, Washington, D.C., P. 272.
2. Neergaard, P. 1997. Seed Pathology. Macmillan Press Ltd., London.
3. Agarwal, V.K. & J.B. Sinclair. 1997. Principles of seed pathology. CRC Press, USA, 539pp.
4. Maude, R.B. 1996. Seedborne diseases and their control: Principles and practices. CABI, UK, 280pp.

4. SEED ENTOMOLOGY 1+1

Principles of seed entomology. Insect pests and their classification based on mode of infestation. Study of major insect-pests of principal crops for seed production and their management practices. Various methods of insect-pest control. Different pesticides, their handling and safe use on seed crops. Study of storage insect-pests infesting seeds, their development and economic importance. Management of storage insect-pests, mites and rodents. Seed sampling and loss estimation. Principles of fumigation, fumigants and their use, effect of different fumigants, preservatives and seed protectants on seed quality. Type of storage structures- domestic and commercial. Principles of insect pollination, role of pollinators in seed production. Augmenting quality seed production through honeybee pollination in cruciferous and forage legumes. Plant protection in bee pollinated crops. Management of pollinators for hybrid seed production.

Practical

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 before and during storage of seed, effect of fumigants on seed viability as affected by seed moisture. Methods of fumigation, dose of fumigants, exposure period, aeration etc. Safety measures in fumigating the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application. Safety measures in plant protection operations. Collection and identification of insect-pollinators, evaluation of their efficacy in cross pollination.

Suggested Readings

1. R.T. Cottong (1963). Insect pests of stored grain and grain products burgess Publ. Co. Minneopolis. Minn. USA.
2. J.A. Anderson and A.W. Aleock (1954). Storage of cereal grain & their products. American Assoc. cereal chemist St. Pauls Minn.
3. B.P. Khare (1972). Insect pests of stored grain and theircontrol in U.P.
4. S.V. Pingale. Handling & storage of food grains
5. R.N. Sinha & Khir. Storage of Food grain
6. H.A.U. Monro (1969). In Manual of Fumigation for insect control, FAO Rome Agril. Studies No. 79.
7. N.S. Agarwal & G.K. Girish (1977). An introduction to action programme to redress on farm storage losses in India FAO/NORAD Seminar on Farm Storage grain in India. Nov. 29-Dec. 8,1977).

5. SEED PHYSIOLOGY 2+1

Chemical composition of seed and its significance in seed quality. Synthesis and accumulation of food reserve. Physiology of seed maturation, factors affecting seed germination, role of different organs of seed in germination. Biochemical changes during germination. Role of promoters and inhibitors. Effect of age, size and position of seed on germination. Seed dormancy- types, mechanism, endogenous and exogenous factors affecting dormancy, role of phytochrome, methods of breaking and inducing dormancy. Seed vigour and its concept, factors affecting seed vigour, physiological and genetical basis of seed vigour, vigour tests, seed vigour and crop performance and yield. Seed invigoration. Seed viability and longevity, pre and post harvest factors affecting seed viability, loss of viability, physiology of seed ageing and viability theories. Chemical composition and structural architecture of the bio-membranes and its impact on seed viability.

Practical

Proximate analysis of chemical composition of seed, germination metabolism, methods for breaking and inducing dormancy in various crop species, vigour tests, kinetics of imbibition and leakages of solutes from hydrated seeds. Volatile aldehyde test, accelerated ageing tests, quantitative tetrazolium test, activity of enzymes, respiratory rates, position, weight and size of seed in relation to germination.

Suggested Readings

1. Bewley, J.D., and L. Black, 1982. Physiology and Biochemistry of seeds in relation to germination, Vol.1 and Vol.11, Springer-Verlag, Berlin Heiderberg, Neew York.
2. Kozlowski, T.T. 1972. Seed Biology, Vol.1, Academic Press, London.
3. Khan, A.A. 1977. The physiology and Biochemistry of seed dormancy and germination, North Holland Publishing Co., Amsterdam, New York.
4. Purseglove, J.W. 1977. Tropical crops of Monocotyledons, Longmans, Green and Co., Ltd., London.
5. Purseglolve, J.W., 1977. Tropical crops of Dicotyledons, Longmans, Green and Co., Ltd., London.
6. Ovcharov, K.E. 1977. Physiological basis of seed germination, Amerind Publishing Co., New Delhi and New York.
7. Thompson, J.R. 1977. Advances in Research and Technology of Seeds, part - 1,3 & 4, centre for Agrl. Publishing and Documentation, Washington.
8. Mayer, A.M. and A.P. Mayber, 1989. Germination of seeds, Pergamon Press, Oxford.
9. Jaima Kigel, J. and G. Galili, 1997. Seed development and germination. Marcel Dekker, New York.
10. Lang. G.A. 1997. Plant dormancy, physiology, biochemistry and molecular biology, Cab International U.K.

6. CULTIVAR PURITY TESTING

Objectives of cultivar purity test, general principles and methods, use and limitations of laboratory, greenhouse and field plot methods. Morphological characters of seed, seedling and adult plants of major crops. Physiological, chemical and biochemical tests for varietal purity such as phenol and peroxidase. Electrophoresis of protein and isozymes, DNA fingerprinting and their use in varietal registration and purity. Use of computer based machine vision for varietal identification. DUS testing. Plant variety protection (PVP), UPOV guidelines and Seeds Act.

Practical

Varietal purity testing by grow-out test in hybrid cotton, sunflower, castor, vegetable and any other crop. Study of diagnostic seed traits in different crops. Variety purity testing in wheat and pearlmillet by phenol

test, peroxidase test for differentiating soybean varieties, use of other laboratory tests viz. KOH-Bleach, FeSO4, fluorascence tests. Electrophoresis in hybrid seeds and its comparison with GOT. Use of other laboratory tests viz., KOH-Bleach, $FeSO_4$, fluroescence tests etc.

Suggested Readings

1. Association of Official Seed Analysts, 1991. Cultivar purity testing handbook, AOSA, cont. No. 33-88p.
2. R.J. Cooke and J.C. Reeves (1998). Cultivar identification: General discussion and review of new methods. In Encyclopedia of seed production of world crops. Ed. A. Fenwick Kelly and RAT George. John Willy and sons, West Sussen, England.
3. B.D. Hames and D. Rickwood (1990). Gel electrophoresis of proteins. A practical approach. Oxford University Press, Oxford, England.
4. Handbook of variety testing growth chamber - Greenhouse testing procedures: Variety identification. Ed. R.C. Payne. The International Seed Testing Association, Zurich, Switzerland, 1993.
5. Handbook of variety testing. Electrophoresis Handbook: Variety identification Ed. R.J. Cooke, International Seed Testing Association, Zurich, Switzerland, 1992.
6. Handbook of variety testing. Rapid chemical identification Technique Ed. R.C. Payne. International Seed Testing Association, Zurich, Switzerland, 1993.
7. Seed Testing Rules (1999). International Seed Testing Association, Zurich, Switzerland.

7. SEED PRODUCTION IN FORAGE AND PASTURE CROPS 1+1

Important pasture and forage crops in India. Seed requirement and production. Flower structure, floral biology and pollination behaviour. Maintenance of varietal purity, genetic shifts in generation system of seed multiplication, kind of variety, pure line, synthetic or hybrid, apomictic grasses. Improvement of apomictic grasses, selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting pelleting, fertilizer and manure requirement, isolation distances, weed control, pollination and seed setting, seed shattering, stage of harvest, seed collection, seed processing, seed treatment, seed storage, seed viability of grasses.

Practical

Study of flower structure, seed identification, characteristics of released

varieties, maturity indices for harvest, laboratory analysis of parameters, laboratory germination methods.

Suggested Readings

1. Fairly, D.T. and J.C. Hampton (1997). Forage seed production Vol.1. Temperate species, CAB international, U.K.
2. Froma, J. (1997). Temperate forage legumes. CAB international U.K.
3. Gutterridge, R.G. (1997). Forage tree legumes in tropical agriculture CAB international U.K.
4. Bradrock, W.L. (1975). Advances in Research and Technology of seed, Part-I, Centre for Agricultural, Publishing and documentation, Washington.

8. SEED PRODUCTION IN VEGETABLE, FLOWER AND MEDICINAL PLANTS 2+1

History of vegetable seed industry. Classification of vegetable crops based on pollination and reproduction behaviour. Seed morphology and development in vegetable crops. Land requirement, isolation, season, planting time, nursery management, seed rate, roguing, seed production procedure. Hybrid seed production in tomato, brinjal, chillies, watermelon, root crops, onion, cucurbits and cole crops. Seed extraction and post harvest care. Role of plant growth regulators in hybrid seed production, maintenance of varieties and inbred lines. Self-incompatibility in cole crops and maintenance of cole crop variety. Seed multiplication ratio, role of bees as pollinators. Plant protection measures in vegetable seed production. History of floriculture seed industry. Selection of area for seed production of self-pollinated crops-annuals, biennials and perennials. Seed production of cross-pollinated crops. Hybrid seed production. Method of sowing, planting density, weeding, disease control, harvesting methodand time. Cleaning and grading of flower seeds. Germination, viability, dormancy and morphology of the seeds of ornamental plants. Plant protection of flower seeds. Seed production of important flower crops-Ageratum, Antirrhinum, China-aster, Carnation, Gypsophila, Static stock, Pansy, Marigold, Larkspur, Lupinus and Petunia. Commercial production of vegetatifely propagated flowers e.g. Gladiolus, Tulips, Chrysanthemum etc. Seed production in Cassia, Catharanthus, Gymnema, Rosella, Rowlfia, Solanum and Plantago.

Practical

Nursery requirements of different vegetables and flower crops. Seedling age for transplanting, agronomical management, floral structure and

floralbiology. Collection of pollen and storage, pollen dispersal, isolation distance. Hand emasculation and pollination for hybrid seed production. Curing of bulbs, rhizomes, corms etc.

Suggested Readings

1. Agrawal, R.L. (1996). Seed Technology, IBH publication Co., New Delhi.
2. Bose, T.K., S.K. Mitra and N.K. Sadhur (1990). Propagation of tropical and subtropical horticultural crops, Naya Prakash, Calcutta.
3. Duffus, C. and C. Slaughter. Seeds and their uses (1980). John Wiley and Sons, New York.
4. Feistritser, P. and A.F. Kelly (1970). Improved seed production, FAO, Rome, George, A.T.

9. EMERGING TRENDS IN SEED QUALITY ENHANCEMENT 1+1

Concept and significance of quality enhancement. Seed treatments, history, principles and methods of seed treatment, seed treatment machinery, film coating, seed tapes, mats, pelleting, seed colouring, seed priming, priming agents, physical seed treatment. Synthetic seeds- concept of synthetic seed, importance, historical development, somatic embryogenesis. Embryo encapsulation systems, hardening of artificial seeds. Cryopreservation, storage, desiccation tolerance, somaclonal variation and their control. Use of botanicals in improving seed quality.

Practical

Seed treating equipments - slurry and mist-o-matic, film coating. Priming-hydration and dehydration, study on the effect of priming. Method for hydrogel encapsulation on artificial endosperms, hydrophobic coating.

Suggested Readings

1. Thompson, J.R. (1977). Advances in Research and Technology of seeds, Part. 3 & 4, Centre for Agricultural Publishing and Documentation, Washington.

10. SEED PRODUCTION IN FRUITS AND PLANTATION CROPS 1+1

Seed production and handling in perennial fruit crops like mango, guava,

papaya, citrus, ber, amla, and jamun. Seed collection and viability maintenance. Germination; problems and improvements. Vegetative propagation. Seed production and handling in plantation crops like coffee, tea, cocoa, rubber, cardamom, pepper, clove, coconut, nutmeg, arecanut. Seed collection and viability maintenance.

Practical

Isloation distance determination, floral biology, maturity indices, selection of trees, seed collection, assessment of critical moisture, maintenance of viability in recalcitrant seeds, germination improvement, visit to seed orchards.

Suggested Readings

1. Agrawal, R.L. 1996. Seed Technology, IBH publication Co., New Delhi.
2. Bose, T.K., S.K. Mitra and N.K. Sadhur (1990). Propagation of tropical and subtropical horticultural crops, Naya Prakash, Calcutta.
3. Duffus, C. and C. Slaughter, Seeds and their users (1980). John Wiley and Sons, New York.
4. Feistrister, P. and A.F. Kelly (1970). Improved seed production, FAO Rome.

Appendix I

List of Participants in the workshop on course curriculum of Genetics and Plant Breeding (M. Sc.) held at the Division of Genetics, IARI, New Delhi on 27-28 April, 2001.

1. Dr. P.L. Gautam, National Director, NATP Campus, New Delhi
2. Dr. N.L. Maurya, ADG (Acdn.), ICAR, KAB, Pusa, New Delhi
3. Dr. B.B. Singh, Head, Division of Genetics, IARI, New Delhi
4. Dr. R.D. Singh, Professor, Division of Genetics, IARI, New Delhi
5. Dr. B.S. Dhillon, Director, N.B.P.G.R., Pusa Campus, New Delhi
6. Dr. C.H. Mishra, Professor & Head (GBP), NDUA&T, Faizabad
7. Dr. Ramkrishna, Professor, GBP, CSAUA&T, Kanpur
8. Dr. S.C. Mani, Professor, GBPUA&T
9. Dr. S.K. Sharma, Professor, GPB, H.P.K.V., Palampur
10. Dr. P.M. Salimath, Professor & Head, GPB. UAS, Dharwad
11. Dr. D. R. Satija, Senior Biom. Geneticist, GPB, PAU, Ludhiana
12. Dr. S.R. maloo, Professor, GPB, MRPU, Udaipur
13. Dr.S.P. Singh, Dean, Faculty of Agricultural Botany, CCS Meerut University, Meerut
14. Dr. M.L. Saini, Professor, GPB, CCSHAU, Hisar
15. Dr. K. Pushkaran, Professor & Head, GPB, KAU, Thrissur, Kerala
16. Dr. C.B. Tiwari, GPB, UP College, Varanasi.
17. Dr. A.K. Fazlullah Khan, Professor (Genetics), TNAU, Coimbtore
18. Dr. S.N. Bandya, Professor & Head, G.A.U., Sardar Krushi Nagar, Ahemdabad
19. Dr. T. Nageshwar Rao, Associate Professor GPB, ANGRAU, Hyderabad
20. Dr. R.S. Kulkarni, Professor & Head, GPB, UAS, Bangalore
21. Dr. N.C. Singhal, Professor, SST, IARI, New Delhi
22. Dr. S.S. Singh, Division of Genetics, IARI, New Delhi
23. Dr Shanti Chandrasekaran, Division of Genetics, IARI, New Delhi
24. Dr. Dalmir Singh, Division of Genetics, IARI, New Delhi
25. Dr. S.M.S. Tomar, Division of Genetics, IARI, New Delhi
26. Dr. S.K. Mishra, Division of Genetics, IARI, New Delhi

27. Dr. K.V. Prabhu, Division of Genetics, IARI, New Delhi
28. Dr. B.M. Prasanna, Division of Genetics, IARI, New Delhi
29. Dr. Anju Mahandru, Division of Genetics, IARI, New Delhi
30. Dr. S.S. Yadav, Division of Genetics, IARI, New Delhi
31. Dr. A.K. Singh, Division of Genetics, IARI, New Delhi
32. Dr. Sujay Rakshit, Directorate of Maize Research, IARI, New Delhi
33. Mr. G.P. Mishra, M.Sc. Student, Division of Genetics, IARI, New Delhi
34. Dr. J.N. Singh, Division of Genetics, IARI, New Delhi
35. Dr. V.P. Singh, Rice Section, Division of Genetics, IARI, New Delhi
36. Dr. B. Sharma, Ex-Head, Division of Genetics, IARI, New Delhi
37. Dr. K.R. Sarkar, Ex-Professor, Division of Genetics, IARI, New Delhi
38. Dr. M.C. Tyagi, Ex-Principal Scientist, Division of Genetics, IARI, New Delhi
39. Dr. H.B. Chaudhary, Division of Genetics, IARI, New Delhi

Appendux II

List of participants in the workshop on course curriculum of Seed Science and Technology held at National Academy of Agricultural Research Management, Hyderabad on April, 6-7, 2001.

1. Dr. S.L. Mehta, Former DDG(Edn.), ICAR, New Delhi
2. Dr. J.C. Katyal, Director, NAARM, Hyderabad
3. Dr. N.L. Maurya, ADG, ICAR, New Delhi
4. Dr.N.C. Singhal, Professor, SST, 1ARI, New Delhi
5. Dr. Rame Gowda, UAS, Bangalore
6. Dr. B.N. Narkhede, MPAU, Rahuri
7. Dr. V.K. Agarwal, GBPUA&T, Pantnagar
8. Dr. P.C. Gupta, GBPUA&T, Pantnagar
9. Dr. P.K. Agarwal, MD, Prasha Agri. Consultants, New Delhi
10. Dr. K. Vanangamudi, TNAU, Coimbatore
11. Dr. A. Bharathi, TNAU, Coimbatore
12. Dr. R.K. Chowdhury, PC, NSP, New Delhi
13. Dr. M. Shekhargouda, UAS, Dharwad
14. Dr. Ashok Gaur, Iari, New Delhi
15. Dr. A.S.N. Reddy, Hyderabad
16. Dr. K.Kant, IARI, New Delhi
17. Dr. M. Hossain, BCKV, Nadia, West Bengal
18. Dr. K.P.R. Prasanna, UAS, Bangalore
19. Dr. B.M.M. Reddy, ANGRAU, Hyderabad
20. Dr. K. Keshavulu, ANGRAU, Hyderabad
21. Dr. S.N. Sinha, 1AR1, Karnal
22. Dr. V. Shankaran, NSC, New Delhi
23. Dr. M.B. Kurdikeri, UAS, Dharwad
24. Dr. P. Sahoo, OUAT, Bhubanseswar
25. Dr. (Ms) M. Dadlani, IARI, New Delhi
26. Dr. D. M. Hedge, DOR, Hyderabad
27. Dr. A.R.G. Ranganatha, DOR, Hyderabad

28. Dr. S. Sudheer Kumar, ANGRAU, Hyderabad
29. Dr. J. Ravindra Reddy, ANGRAU, Hyderabad
30. Dr. T. Nageswara Rao, ANGRAU, Hyderabad
31. Dr. S.N. Saha, Jt. Director, NAARM, Hyderabad
33. Dr. K.H. Rao, NAARAm, Hyderabad
34. Dr. C.P. Vaish, CSAUA&T, Kanpur