FACULTY OF AGRICULTURAL SCIENCES

ORDINANCE

M.Sc. Agriculture Genetics & Plant Breeding

(2023-24)

SHREE GURU GOBIND SINGH TRICENTENARY UNIVERSITY
GURUGRAM (DELHI-NCR)

Syllabus of Common Courses for PG programmes:

11110101/11060141/11080101/11090101/11100101	:	Library and information services	0+1

Objective

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

Practical

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

11110102/11100102/11090102/ 11080102/11060142	**:**	**Technical writing and communications skills**	**0+1**

Objective

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

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.; • Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, 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

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

10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

11110202/11100201/11090201/ 11080201/11060241	**:**	**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 biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
7. 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; The Biological Diversity Act, 2002.

11110203/11100202/11090202/ 11080202/11060242	**:**	**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 vaccupets;
- 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

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

11110301/11100301/11060341/ 11080301/11090301	**:**	**Agricultural research, research ethics and rural development programme**	**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

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

16.2 Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Course Code	University Code	Course title	Credit hours
STAT 511		Experimental Designs	2+1
STAT 512		Basic Sampling Techniques	2+1
STAT 521		Applied Regression Analysis	2+1
STAT 522		Data Analysis Using Statistical Packages	2+1

Syllabus of Sporting Courses for PG programmes

11100221/11110216/11060253/ 11080217/11090219	:	Experimental Designs	2+1

Aim of the course

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

Unit I

Need for designing of experiments, characteristics of a good design. Basic principles of designs-randomization, replication and local control.

Unit II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

VI. Practical

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
- Analysis with missing data,
- Split plot and strip plot designs.

VII. Suggested Reading

- Cochran WG and Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- Dean AM and Voss D. 1999. *Design and Analysis of Experiments*. Springer.
- Montgomery DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.
- Federer WT. 1985. *Experimental Designs*. MacMillan.
- Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
- Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

11090312/11080309/11060253/ 11110306/11100312	:	Basic Sampling Techniques	2+1

Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

Suggested Reading

- Cochran WG. 1977. *Sampling Techniques*. John Wiley.

- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

	:	**Applied Regression Analysis**	**2+1**

Aim of the course

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

Unit I

Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Unit II

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

Unit III

Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

Unit IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection;
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves, fitting oforthogonal polynomials.

Suggested Reading

- Kleinbaum DG, Kupper LL, Nizam A. 2007. *Applied Regression Analysis and Other Multivariable Methods* (Duxbury Applied) 4th Ed.
- Draper NR and Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
- Koutsoyiannis A. 1978. *Theory of Econometrics*. MacMillan.
- Kutner MH, Nachtsheim CJ and Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

	:	**Data Analysis Using Statistical Packages**	**2+1**

Aim of the course

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

Unit I

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit II

Test for normality; Testing of hypothesis using chi-square, *t* and *F* statistics and Z-test.

Unit III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

Unit IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

Suggested Reading

- Anderson C.W. and Loynes R.M. 1987. *The Teaching of Practical Statistics*. John Wiley.
- Atkinson A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.
- Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- Cleveland W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- Erickson B.H. and Nosanchuk T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.
- Snell E.J. and Simpson HR. 1991. *Applied Statistics: A Handbook of GENSTAT Analyses*. Chapman and Hall.
- Sprent P. 1993. *Applied Non-parametric Statistical Methods*. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.
- Velleman PF and Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.
- Weisberg S. 1985. *Applied Linear Regression*. John Wiley.
- Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall. Restructured and Revised Syllabi of Post-graduate
- Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.

- Cleveland WS. 1994. *The Elements of Graphing Data*, 2nd Ed., Chapman & Hall

COURSE ORDINANCE

Genetics & Plant Breeding

Course Title with Credit Load
M.Sc. Ag. (Genetics and Plant Breeding, GPB)

ICAR Code	Course Code	Course Title	Credit Hours
GPB 501*	11100103	Principles of Genetics	3 (2+1)
GPB 502*	11100105	Principles of Plant Breeding	3 (2+1)
GPB 503*	11100107	Fundamentals of Quantitative Genetics	3 (2+1)
GPB 504	11100109	Varietal Development and Maintenance Breeding	2 (1+1)
GPB 505	11100111	Principles of Cytogenetics	3 (2+1)
GPB 506*	1110113	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 507	11100203	Breeding for Quality and Special Traits	3 (2+1)
GPB 508	11100205	Mutagenesis and Mutation Breeding	3 (2+1)
GPB 509	11100207	Hybrid Breeding	3 (2+1)
GPB 510	11100209	Seed Production and Certification	2 (1+1)
GPB 511	11100211	Crop Breeding-I *(Kharif* Crops)	3 (2+1)
GPB 512	11100213	Crop Breeding-II *(Rabi* Crops)	3 (2+1)
GPB 513	11100215	Breeding Vegetable Crops	3 (2+1)
GPB 514	11100302	Breeding Fruit Crops	3 (2+1)
GPB 516	11100304	Breeding for Stress Resistance and Climate Change	3 (2+1)
GPB 517	11100306	Germplasm Characterization and Evaluation	2 (1+1)
GPB 518	11100308	Genetic enhancement for PGR Utilization	2 (1+1)
GPB 591	11100223	Seminar	1(1+0)
GPB 599	11100401	Thesis/ Research	30 (0+30)

COURSE CONTENTS

Course Title : Principles of Genetics*
Course Code : 11100103
Credit Hours : 3 (2+1)
Why this course?
Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.
Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- 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.
- Detection of transgenes in the exposed plant material.
- Visit to transgenic glasshouse and learning the practical considerations.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested reading

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

Course Title : Principles of Plant Breeding*
Course Code : 11100105
Credit Hours : 3(2+1)
Why this course?

Development of plant variety is the ultimate aim of any plant breeding program. A postgraduate in the subject of agriculture must know what the different selection methods, techniques and related crop improvement strategies are. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour. Impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreeds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

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

Unit VI

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

Unit VII

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

Practical

- 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.
- Prediction of performance of double cross hybrid.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
- Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches.* Narosa Publishing House.
- Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
- George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons. Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
- Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi

- 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.
- Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi. Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society. Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

Course Title : Fundamentals of Quantitative Genetics*
Course Code : 11100107
Credit Hours : 3 (2+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- Analysis and interpretation of variability parameters.
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D2 analysis.
- Genotypic and phenotypic correlation analysis and interpretation.

- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation.
- A, B and C Scaling test.
- L × T analysis and interpretation, QTL analysis.
- Use of computer packages.
- Diallel analysis.
- G × E interaction and stability analysis.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures,
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

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

e-Suggested Reading

www.iasri.icar.gov.in www.hau.ac.in/OPstat

Course Title : Varietal Development and Maintenance Breeding
Course Code : 11100109
Credit Hours : 2(1+1)
Why this course?

It is an indispensable course which apprise the students about various practices and procedures in the development of a variety and steps to maintain the purity of varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

Aim of the course

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

Theory

Unit I

Variety Development systemsand Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Unit III

Maintenance of varieties in self and cross-pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit IV

Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit V

Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

Practical

- Identification of suitable areas/ locations for seed production.
- Ear-to-row method and nucleus seed production.
- Main characteristics of released and notified varieties, hybrids and parental lines.
- PGMS and TGMS.
- Identification of important weeds/ objectionable weeds.
- Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops.
- Hybrid seed production technology of important crops.
- DUS testing and descriptors in major crops.
- Variety release proposal formats in different crops.

Teaching methods

- Power point presentation
- Chalk and Board

- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

Pass out student will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

Suggested Reading

- Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH. Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.
- McDonald MB Jr and Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- Poehlman JM and Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH. Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani. 2015 Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill

Course Title : **Principles of Cytogenetics**
Course Code : **11100111**
Credit Hours : **3 (2+1)**

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, *Triticale, Brassica***,** and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit V

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

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

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson Edu. 9th edition. Carroll M. 1989. *Organelles*. The Guilford Press.
- Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications.
- Darlington CD and La Cour LF. 1969. *The Handling of Chromosomes*. George Allen & Unwin Ltd.
- Elgin SCR. 1995. *Chromatin Structure and Gene Expression*. IRL Press, Oxford.
- Gupta PK and Tsuchiya T. 1991. *Chromosome Engineering in Plants: Genetics, Breeding and Evolution*. Part A.

- Gupta PK. 2010. *Cytogenetics*. Rastogi Publishers. Johannson DA. 1975. *Plant Micro technique*. McGraw Hill.
- Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Khush GS. 1973. *Cytogenetics of aneuploids*. Elsevier. 1 edition.
- Roy D.2009. *Cytogenetics*. Alpha Science Intl Ltd.
- Schulz SJ.1980. *Cytogenetics- Plant, animals and Humans*. Springer.
- Sharma AK and Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth- Heinemann publisher 2014.3rd edition
- Singh RJ. 2016. Plant *Cytogenetics* 3rd Edition. CRC Press.
- Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ. 1 edition, Springer pub. Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

Course Title : Molecular Breeding and Bioinformatics*
Course Code : 11100113
Credit Hours : 3(2+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F_2s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

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

Unit III

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

Unit IV

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

legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

Practical

- 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; 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.
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder.
- Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensemble);
- Primer designing- Primer 3/ Primer BLAST.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning Outcome

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

Suggested Reading

- Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics.*
- John Wiley and Sons.
- Brown TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition
- Chawala HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt.Ltd.
- Chopra VL and 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 and Messing JW. 1988. *An Introduction to Recombinant DNA Technology*

- *Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.
- Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*.
- Birkhäuser.
- Lewin B. 2017. *Genes XII*. Jones & Bartlett learning, 2017.
- Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology.* CRC Press.
- Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi. Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

Course Title : **Breeding for Quality and Special Traits**
Course Code : **11100203**
Credit Hours **: 3(2+1)**

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice; Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison.
- Quality parameters evaluation in wheat, pulses and oilseeds.
- Evaluation of quality parameters in cotton, sugarcane, and potato.
- 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.
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding - Biotechnological and Conventional approaches***,** Narosa Publications Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.
- FAO 2001. *Speciality Rices of the World - Breeding, Production and Marketing*. Oxford & IBH,1 Nov 2001.
- Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
- Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA. 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 Publishers, New Delhi.
- Singh RK, Singh UK and Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

Course Title : Mutagenesis and Mutation Breeding
Course Code : 11100205
Credit Hours : 3 (2+1)

Why this course?

The knowledge of this course will enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding. It will also give in depth knowledge

about genomics, allele mining, TILLING, etc. and their utilization in crop improvement programmes.

Aim of the course

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

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. Paramutations in crops plants.

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

Unit III

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

Unit IV

Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit V

Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro* mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical

- Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens.
- Learning on Radioactivity- Production 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; Procedures in combined mutagenic treatments.
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature; Study of M_1 generation – Parameters;
- Study of M_2 generation – Parameters.
- 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 M_2 and M_3 generations.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.
- Chadwick KH and Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer- Verlag.
- Cotton R, Edkin E and Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.
- Shu QY, Forster BP and Nakagawa N. 2012. *Plant Mutation Breeding and Biotechnology.*
- Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).
- Singh BD. 2003. *Genetics*. Kalyani Publishers, New Delhi. Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall. www.barc.gov.in

Course Title : Hybrid Breeding
Course Code : 11100207
Credit Hours : 3(2+1)

Aim of the course:

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

Unit I

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis –

Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

Unit III

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

Unit IV

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

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

Unit V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed- mustard, sunflower, safflower and castor oilseed crops and pigeon pea. This course will expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

Practical

- Characterization of male sterile lines using morphological descriptors.
- Restorer line identification and diversification of male sterile sources.
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them.
- Diversification and restoration; Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea.
- 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.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz

- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Agarwal RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. Science Publisher London.
- Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.
- Ben HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.
- Chal GS and Gossal SS. 2002. *Principles and procedures of Plant Breeding, Biotechnology and Convetional Approaches*. Narosa Publishing House. New Delhi
- De JG. 1988. *Population Genetics and Evolution*. Springer-Verlag. 30 January 2012 Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.
- Mettler LE and Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall. 25 April 1988
- Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons. 2013 Mukherjee BK. 1995.*The Heterosis Phenomenon*. Kalyani Publishers, New Delhi.
- Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.
- Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin. 30 May 1997 Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- Srivastava S and Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ. Virmani SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of" Theoretical and Applied Genetics*", Springer-Verlag.

Course Title : Seed Production and Certification
Course Code : 11100209
Credit Hours : 2(1+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Practical

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

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student’s presentations

Learning outcome

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

Suggested Reading

- Agrawal PK and Dadlani M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- Agrawal RL. 1997. *Seed Technology,* Oxford & IBH Publishing.
- Anon, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.
- Anon. 1999. *Manual of Seed Certification procedures.* Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi. Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.
- Mc Donald MB and Copeland LO. 1997. *Seed Science and Technology*, Scientific Publisher, Jodhpur.
- Ramamoorthy K, Sivasubramaniam K and Kannan M. 2006. *Seed Legislation in India*. Agrobios (India), Jodhpur, Rajasthan.
- Singhal NC. 2003. Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi
- Tunwar NS and Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.
  e-Resources www.gov.mb.ca, www.agricoop.nic.in ,www.agri.nic.in ,www.fao.org, www.seednet.gov.in

Course Title : Crop Breeding I (*Kharif* Crops)
Course Code : 11100211
Credit Hours : 3(2+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

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

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

Small millets: Evolution and distribution of species and forms - wild relatives and

germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II

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

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

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

Unit III

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

Unit IV

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

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

Unit V

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

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

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

heterosis breeding, released varieties, Achievements of important spice crops. Example of MAS used for improvement.

Practical

- Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton.
- Study of range of variation for yield and yield components.
- Study of segregating populations in cereal, pulses and oilseed crops.
- Learning on the crosses between different species; attempting crosses between black gram and green gram.
- 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 the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval.
- Practical learning on the cultivation of fodder crop species on sewage water, analyzing 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.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
- Bahl PN and 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 and 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 and Kauffman HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.
- Kannaiyan S, Uthamasamy S, Theodore RK and Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.
- Murty DS, Tabo R and Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*.
- ICRISAT, Patancheru, India.
- Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani Publishers.
- Parthasarathy VA. 2017. *Spices and Plantation Crops Vol.1* (*Part A*) *Breeding of Horticultural Crops* Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
- Poehlman, JM. 1987. *Breeding of Field Crops*. AVI Publishing Co. Inc. East Post Connecticut, USA.
- Ram HH and Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
- Sharma, AK. 2005. *Breeding Technology of Crop Plant*. Yesh Publishing House, Bikaner Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.
- Singh HG, Mishra SN, Singh TB, Ram HH and Singh DP. (Eds.). 1994. *Crop Breeding in India*.
- International Book Distributing Co.
- Walden DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.

Course Title : **Crop Breeding-II (*Rabi* Crops)**
Course Code **: 11100213**
Credit Hours **: 3(2+1)**

Why this course?

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

Aim of the course

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

Theory

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress

resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

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

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

Unit II

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

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

Unit III

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

resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

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

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number.

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

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

Unit V

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

Practical

- Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower.
- Study of range of variation for yield and yield components.
- Study of segregating populations in cereal, pulses and oilseed crops.
- Use of descriptors for cataloguing; Learning on the crosses between different species.
- Trait based screening for stress resistance.
- Learning on the Standard Evaluation System (SES) and descriptors.
- Use of software for database management and retrieval.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

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

Course Title : Breeding Vegetable Crops
Course Code : 11100215
Credit Hours : 3(2+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II

Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III

Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV

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

Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato, and tapioca.

Unit V

Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

Practical

- Selection of desirable plants from breeding population, observations, and analysis of various qualitative and quantitative traits in germplasm.
- Hybridization and handling segregating generations.
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops.
- Hybrid seed production of vegetable crops in bulk.
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops.
- Demonstration of sib-mating and mixed population.
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques.
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After completion of this course the students will be able to know about the different

Suggested Reading

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

- Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publishers, New Delhi. Singh BD. 1983. *Plant Breeding*. Kalyani Publishers

Course Title : Breeding Fruit Crops
Course Code : 11100302
Credit Hours : 3(2+1)

Why this course?

This course is aimed to educate the students about the breeding strategies and avenues in Fruit crops.

Aim of the course

To educate students about principles and practices adopted for breeding of fruit crops.

Theory

Unit I

Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.

Unit II

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

Unit III

Apomixis - merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV

Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops andregion specific fruit crops.

Practical

- Germplasm documentation; Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops.
- Pollen germination to study time of anthesis and stigma receptivity.
- Hybridization technique in important fruit crops, hybrid seed collection and raising.
- Colchicine treatment for induction of polyploidy.
- Exposure to resistance breeding and screening techniques.
- Mutation breeding practices raising and evaluation of segregating populations.
- Use of mutagens to induce mutations and polyploidy.
- Visit to Biotechnology Lab and study of *in-vitro* breeding techniques.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After completion of this course the students will be able do the breeding of fruit crops through various conventional and biotechnological methods besides mutation breeding.

Suggested Reading

- Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.
- Chadha KL and Pareek, OP. 1996. (Eds.). *Advances in Horticulture.* Vol. I to IV. Malhotra Publ. House, New Delhi.
- Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.
- Janick and Moore JN. 1996. *Advances in Fruit Breeding*, AVI Pub., USA. Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I to III. John Wiley & Sons.
- Kumar N. 2006. *Breeding of Horticultural Crops - Principles and Practices*. New India Publishing Agency, New Delhi.
- Moore JN and Janick Jules. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK. and Mohanadas S. 2001. *Biotechnology of Horticultural Crops.* Vols. I-III. Naya Prokash, Kolkata.
- Ray PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, New Delhi.
- Simmonds NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

Course Title : Breeding for Stress Resistance and Climate Change
Course Code : 11100304
Credit Hours : 3(2+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness;

Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.
Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/
low temperature, wind, etc.; Stress due to soil factors and mineral toxicity;
Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment. Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

Practical

- Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria.
- Symptoms and data recording; use of MAS procedures.
- 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.
- Evaluating the available populations like RIL, NIL, etc. for pest resistance.
- Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops.
- Breeding for herbicide resistance.
- 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.
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student’s presentations

Learning outcome

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

Suggested Reading

- Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.
- Christiansen MN and Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*.
- Wiley International.
- Fritz RS and Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.
- Li PH and Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York Springer
- Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.
- Maxwell FG and Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons. Wiley-Blackwell.
- Roberto F. 2018. *Plant Breeding for Biotic and Abiotic Stress Tolerance*. Springer. Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths. Sakai A and Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.
- Turner NC and 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**.**

Course Title : Germplasm Characterization and Evaluation
Course Code : 11100306
Credit Hours : 2(1+1)

Why this course?

Students need to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses. This will increase the importance of the germplasm.

Aim of the course

Students will gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, as well as those for resilience to biotic and abiotic stresses that will promote utilisation. Exposure to development of web-based tools for systematic description for efficient use of germplasm.

Theory

Unit I

Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II

Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation, and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Unit III

High throughput phenotyping systems- imaging and image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits - Biochemical and molecular markers for characterization.

Practical

- Field layout and experimental designs; Recording field data on germplasm evaluation in different agri-horticultural crops, post-harvest handling.
- Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing.
- Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.
- Lectures
- Power point presentations
- assignments, quiz
- Group tasks, student's presentations

Learning Outcome

To educate students about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

Suggested Reading

- Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. *Plant Population Genetics, Breeding, and Genetic Resources*, Sinauer Associates, USA.
- Frankel R and Galun E 1977. *Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics*, Springer-Verlag, Berlin, Heidelberg.
- Hayward MD, Bosemak NO and Romagosa I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.
- Holden JHN and Williams JT 1984. *Crop genetic resources: conservation and evaluation*, IBPGR. Puzone, L and Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources*
- *Utilizing Multimedia Database*. NBPGR, New Delhi.
- Rana RS, Sapra RL, Agrawal RC and Gambhir R 1991. Plant Genetic Resources, *Documentation and Information Management*. NBPGR, New Delhi.
- Stoskopf NC 1993. *Plant Breeding: Theory and Practice*, Westview Press.
- Sundeep Kumar, *et al.* 2016. *Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases*. PloS One Vol 11, pages 0167702.
- Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

Course Title : Genetic enhancement for PGR Utilization
Course Code : 11100308
Credit Hours : 2(1+1)

Why this course?

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

Aim of the course

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

Theory

Unit I

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

Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit III

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

Practical

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

Teaching methods

- Lectures
- Power point presentations
- assignments, quiz
- Group tasks, student's presentations

Learning outcome

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

Suggested Reading

- Andey Pereira. 2006. *Plant Reverse Genetics*, Methods and Protocols, Humana Press
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